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JOINT COMMITTEE ON ATOMIC ENERGY

REPORT

OF THE

SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT

ON THE

Five-Year Power Reactor Development Program Proposed by the Atomic Energy Commission

MARCH 1954

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DOCUMENTS EXPEDITING PROJECT

FOREWORD

On July 31, 1953, the Joint Committee on Atomic Energy requested by letter that the Atomic Energy Commission prepare an outline of the objectives it seeks to achieve in the field of reactor development over the next 5 years and of its program for accomplishment of these objectives.

The purpose of this request was twofold: To insure that during the next 5 years the Commission's reactor development program would proceed in an orderly manner toward clear objectives; and to permit the public as well as private industry to have full knowledge of what the Federal Government plans to undertake in this field during the next 5 years so that non-Federal activities may be geared to these plans in the most effective manner.

The Commission submitted its proposed statement of objectives and program in a classified report to the committee dated February 5, 1954, in executive session. Detailed review and discussion of this report has been undertaken by the Research and Development Subcommittee under the chairmanship of Representative Carl Hinshaw.

The report of the subcommittee is attached. Recommendation No. 3 contained in the report has already been carried out in a meeting with the Atomic Energy Commission on March 12. At that meeting, the Commission gave a detailed presentation of the purpose of and the prospects for the pressurized water reactor. Strong assurances were given to the committee that every effort will be made to incorporate into the pressurized water reactor all promising ideas which will help make it more economic and will not unduly delay its completion. In addition, the Commission assured the committee that, whenever possible, the entire 5-year program will be speeded up as a result of any new scientific or engineering advances.

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REPORT FROM THE RESEARCH AND DEVELOPMENT SUBCOMMITTEE OF THE JOINT COMMITTEE ON ATOMIC ENERGY ON THE AEC 5-YEAR POWER REACTOR DEVELOPMENT PROGRAM

On February 5, 1954, the chairman of the joint committee referred to the Subcommittee on Research and Development for review and evaluation the 5-year reactor development program proposed by the Atomic Energy Commission in response to the letter request from the committee on July 31, 1953. This program incorporates the plans for full-scale construction of an atomic powerplant known as the pressurized water reactor which will produce 60,000 kilowatts of electricity.

The proposed 5-year program calls for a research and development program at a cost of $8.5 million per year, and five specific reactor development projects. These projects, their total estimated costs over the entire 5 years, and the dates for estimated completion of plants on an experimental scale are shown below:

Project	Estimated cost [1]	Estimated completion	Experimental scale
	Million		
1. Pressurized water reactor	$85	1957	Full.
2. Boiling water reactor	17	1956	Medium.
3. Sodium graphite reactor	10	1955	Medium.
4. Homogeneous reactor	47	1956–8	Medium.
5. Fast breeder reactor	40	1958	Medium.
Total	199	5 years	

[1] All cost estimates are conditional on annual congressional appropriations.

The subcommittee has held 4 meetings reviewing this program as follows:

February 5, 1954: Dr. L. R. Hafstad, AEC Chief of Reactor Development.

February 24, 1954: Dr. A. T. Weinberg, technical director, Oak Ridge National Laboratory.

March 4, 1954: Dr. C. Starr, Atomic Energy Research Division manager, North American Aviation Co.

March 5, 1954: Dr. W. H. Zinn, director, Argonne National Laboratory.

In addition the subcommittee addressed pertinent questions concerning the program to the following nuclear scientists and engineers:

Dr. Hans Bethe, Cornell University
Mr. Walker Cisler, president, Detroit Edison Co.
Dr. Karl Cohen, Walter Kidde Nuclear Laboratories, Inc.
Mr. William E. Dean, Chief of Power Economics Branch, TVA
Dr. Enrico Fermi, University of Chicago
Dr. L. R. Hafstad, AEC, Chief of Reactor Development
Mr. Murray Joslin, Commonwealth Edison Co. of Chicago
Dr. Kenneth Kingdon, Knolls Atomic Power Laboratory, General Electric Co.
Mr. John R. Menke, Nuclear Development Associates, Inc.
Adm. E. W. Mills, Foster Wheeler Corp.

Dr. I. I. Rabi, Columbia University (chairman, GAC)
Dr. C. Starr, Atomic Energy Research Division manager, North American Aviation Co.
Dr. Edward Teller, University of California
Dr. Charles Thomas, Monsanto Chemical Co.
Dr. A. T. Weinberg, technical director, Oak Ridge National Laboratory
Dr. Eugene P. Wigner, Princeton University
Dr. W. H. Zinn, director, Argonne National Laboratory

The testimony and the letter replies are summarized briefly below.

1. *Concept of the program.*—The idea of setting out a specific program for reactor development is generally regarded as a sound step toward achievement of economic atomic power. Some criticism of the administrative direction of reactor development activities by the Atomic Energy Commission in the past has been expressed by witnesses and correspondents on the grounds that the Commission did not formulate a specific development program earlier on its own initiative.

2. *Selection of these five approaches.*—Out of the large number of possible approaches—perhaps 80 or more—the 5 particular approaches selected by the Commission for its program are generally regarded by those who have expressed their views to the subcommittee as the ones most likely to lead to economic power. There is real confidence that atomic power can be produced at a cost competitive with fossil fuels such as coal and oil within the next decade by exploring these five approaches.

3. *Scale of the program.*—Disagreement as to how fast each project can be pushed profitably was expressed by witnesses. On the whole, the Commission's estimate of the amount of effort which should be devoted to each project is within the range generally approved by those consulted. Strong statements have been received from all witnesses and correspondents in support of speeding up any of these projects whenever scientific and engineering findings may warrant. It was generally felt that larger budgets than those planned for these programs at this time would probably not speed up accomplishment appreciably.

4. *Relative merits of the five projects.*—The 5 projects were divided by most of those consulted into 3 categories: *Short term*, meaning ready for large experimental testing in 2 or 3 years with a good chance of mechanical success; *middle term*, meaning ready for testing on a large scale within 5 years; and *long term*, meaning ready for large experimental testing in not less than 5 years unless some unexpected technical break-through occurs during the next 5 years. The following is the listing under these categories on which most witnesses agreed:

Short term —Pressurized water reactor (formerly CVR)
Sodium graphite reactor (North American)
Middle term—Boiling water reactor (Argonne)[1]
Long term —Homogeneous reactor (Oak Ridge)
Fast breeder reactor (Argonne)

[1] A description of the boiling rector experiment prepared by Dr. W. H. Zinn, Director, Argonne National Laboratory, is attached to this report.

The short term approaches are thought to be least likely ever to produce competitive and low-cost atomic power and the long term most likely to do so.

The consensus of opinion for achievement of economically competitive atomic power as expressed by the witnesses and correspondents is as follows: (No. 1 is most promising, No. 5 least promising.)

No. 1 Homogeneous reactor
No. 2 Fast breeder reactor
No. 3 Boiling reactor
No. 4 Sodium graphite reactor
No. 5 Pressurized-water reactor

Strong emphasis was placed by witnesses before the subcommittee on the enthusiasm of the participants in any project as a large factor in early achievement of the goal of economic atomic power. The proponents of each particular type of reactor proposed for pilot testing appear to have enthusiasm in the prospects for achievement of economic power by the approaches which they advocate. There is apparently little optimism about the chances of producing economic power at an early date along the route of the pressurized-water reactor.

5. *Pressurized water reactor.*—This is the only full-scale plant proposed by the Commission for construction at this time, although it is not as large as might be necessary to achieve maximum economy with this design. However, it is as large as is necessary to get operating experience and prove the design. Most witnesses and correspondents seem to feel that the other approaches will benefit from information and experience gained in the construction and operation of any large-scale plant, including PWR. It is clearly of conservative design and has a poor long-term prospect for producing low-cost atomic power. On the other hand, it is the one approach now ready for full-scale construction as a demonstration of the generation of electricity from atomic energy. The achievement of economic atomic power by this approach will require the very greatest engineering skill, scientific ingenuity, and continuous research and study after the plant starts operating.

The pressurized water reactor might also contribute substantially to carrying out the President's international cooperation proposal. It uses as fuel uranium slightly enriched in the isotope-235. With relatively minor redesign it would operate on natural uranium if heavy water were to be used as a coolant and moderator instead of natural water. Plants of this type could be built in foreign countries with United States assistance at an earlier date than the more novel plants using highly enriched fuels. Thus we believe electric power could be provided at competitive prices in many parts of the world in the next 10 years. Later on, as technology improves, possibly more efficient reactors, using enriched fuels, could also be made available.

As a demonstration of the serious intent of the United States to develop peacetime uses of atomic energy for both ourselves and our allies and as a tool to help gain operating experience on a full-scale plant, the continuation of construction of one large-scale plant such as the pressurized water reactor is important.

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CONCLUSION

The proposed program is the subject of controversy not in its concept but in its estimates of scale of effort and priority of projects. This controversy is the direct result of the natural and desirable optimism of the various project proponents for their own approaches. The most serious criticism which might be leveled at this program is that it overlooks some profitable approaches completely or distorts the levels of effort unduly. No such criticism appears warranted.

RECOMMENDATIONS

1. The joint committee should support the proposed 5-year program for reactor development.

2. The program as a package should be reviewed at least annually to insure that the approaches being followed are still in proper balance and that every advantage is being taken of new developments.

3. A meeting should be held with the Commission before any further action on the pressurized water reactor is undertaken in order to insure that both the committee and the Commission are in agreement on its continuation, appreciate its limitations, and have a clear conception of what it can be expected to accomplish.

Approved March 17, 1954, and reported to the full committee by the subcommittee.

CARL HINSHAW,
Chairman of the Subcommittee.
WILLIAM F. KNOWLAND.
JOHN W. BRICKER.
JOHN O. PASTORE.
JAMES E. VAN ZANDT.
CARL T. DURHAM.
MELVIN PRICE.

Approved March 23, 1954, and adopted by the full committee.

STERLING COLE, *Chairman.*

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
July 31, 1953.

UNITED STATES ATOMIC ENERGY COMMISSION,
Washington, D. C.

(Attention: Mr. Lewis L. Strauss, Chairman.)

GENTLEMEN: The joint committee is about to conclude its executive and open hearings in which it has explored some of the problems involved in definition of a Federal policy on atomic power development in private enterprise.

Our hearings have made clear that the entire atomic power development problem is one of considerable complexity. With this thought in mind, it has occurred to us that there are certain steps which the Atomic Energy Commission might take during the next few months which would be particularly helpful, not only to the joint committee in its examination of these problems, but also to the many other interested parties.

1. Even though the Commission has concluded that the time has not yet arrived when "any industrial, commercial, or other nonmilitary uses of fissionable material of atomic energy has been sufficiently developed to be of practical value," as set forth in section 7 (b) of the act, it might, nevertheless, be of considerable assistance if the Commission were to prepare an estimate of the "social, political, economic, and international effects of such use" as now appear. This estimate would be helpful in our further consideration of the problem even though it is appreciated that such an estimate might be of an interim nature if the circumstances envisioned by the act have not, in fact, fully developed at this time.

2. There have been a substantial number of references by witnesses during our hearings to the indefiniteness of Commission plans for research and development in the field of atomic power components, pilot plants, and prototypes. It would seem appropriate that plans for Commission activity should be set forth in a concise manner so that all interested companies, groups, organizations or individuals can henceforth have no doubt about the Federal program under the existing act. I have in mind here that a 3- to 5-year program consisting of specific reasearch and development projects—perhaps including construction items—might be set forth so that others could adjust their plans accordingly. Even though appropriations are determined on a year-to-year basis, it should be possible to carry out planning and programing over a longer term.

3. As you note in your letter of June 2 (1953), policy decisions on some aspects of the nuclear power program "will necessarily be subject to revision from time to time as experience and technical progress dictate." Nevertheless, the particular policy problems are important matters in the growth of private industrial participation. Your policy decisions on these five matters would be of real interest, not only to the joint committee, but to many of the companies, groups, and individuals who have recently testified on this subject.

Thank you very much for your attention to these matters.

Sincerely yours,

STERLING COLE, *Chairman.*

UNITED STATES ATOMIC ENERGY COMMISSION,
Washington D. C., March 12, 1954.

HON. STERLING COLE,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR MR. COLE: In accordance with Mr. Strauss' instructions before he left town, I am forwarding herewith a copy of the draft for an unclassified version of the reactor development program. It was from this draft that the summary sent to you on March 5 was taken. * * *

Sincerely yours,

K. D. NICHOLS, *General Manager.*

ABSTRACT OF UNCLASSIFIED MATERIAL FROM CLASSIFIED AEC REPORT TO THE JCAE, "PROGRAM PROPOSED FOR DEVELOPING NUCLEAR POWERPLANT TECHNOLOGY"[3]

The Atomic Energy Commission program for the development of nuclear powerplant technology is based on a 5-way approach to the problem of attaining economically competitive power from nuclear fuels.

This program, which involves 1 full-scale experimental power project, already underway, and 4 prototype or pilot size power reactor projects, was described in detail in a classified report recently submitted to the joint committee.

The Commission plan calls for a developmental effort, including 5 different types of experimental power reactor systems in the civilian power reactor field. It is expected to take from 4 to 6 years to carry out the program.

All the reactor development expenditures have produced a large amount of technology applicable to the design and construction of civilian industrial nuclear powerplants. Many studies by the AEC and its contractors made on the basis of this technology lead to a program of research, development, construction, and operation of reactors along five major technical approaches:

(1) Pressurized water, which calls for the building of the country's first full-scale nuclear powerplant, the pressurized water reactor, now under development by Westinghouse Electric Corp. This plant's power output will total about 264,000 kilowatts of heat from which the plant will produce at least 60,000 kilowatts of electricity net, not including power for operating auxiliary equipment.

(2) Boiling water, which explores further the concept of boiling water in a reactor to create steam for a turbine directly. This concept appears promising according to preliminary experiments by Argonne National Laboratory. An experimental boiling water reactor, with an output of 20,000 kilowatts of heat and 5,000 kilowatts of electricity, will be fabricated after the necessary research and development.

[3] The joint committee was informed on March 19, 1954, that the Commission had approved this draft as final on that date.

(3) Sodium graphite, which is along the line of extensive investigations by North American Aviation, Inc., for the AEC. A sodium reactor experiment, to produce 20,000 kilowatts of heat and not be equipped with a turbogenerator, will be the first reactor of the sodium-graphite type.

(4) Fast breeder, which will take the next steps in developing a practical power reactor that will also breed new fissionable material, that is, produce as much as it consumes or more. Research and development will continue; an experimental breeder reactor No. 2, producing 62,500 kilowatts of heat, is to be built as a scale-up from the original experimental breeder reactor, which has an output of only 1,400 kilowatts. This first EBR demonstrated breeding on a very small scale and produced the country's first power from nuclear fuel in token amounts and on an experimental, uneconomic basis. Argonne National Laboratory is the developer of both EBR's.

(5) Homogeneous, which will further the development of reactors containing fuel in a water solution. First, homogeneous reactor experiment No. 2, with an output of 5,000 kilowatts of heat, will be fabricated as a scale-up from the 1,000-kilowatt first homogeneous reactor experiment, the country's second nuclear power plant, located at Oak Ridge National Laboratory. Like EBR No. 1, HRE No. 1 is a very small, uneconomic, experimental powerplant. A turbogenerator and a chemical processing plant are included in the HRE No. 2. Next, homogeneous thorium reactor is projected as a scale-up to 65,000 kilowatts of heat with the addition of production of uranium 233 from thorium. Turbogenerator and chemical processing plants for the liquid fuel and for the thorium blanket are included. Considerable research and development will be necessary for both reactor projects.

In addition to these major projects, the AEC plans to continue its program of general research and development in exploration of other types of reactors on which less work has been done, and to advance technology in such fields as reactor physics, radiation effects on materials, shielding, fuel elements and their materials, instrumentation and control, coolants, and heat transfer. These general investigations also include the recovery of uranium, plutonium, and thorium from used fuel, treatment and disposal of highly radioactive reactor wastes, and utilization of the radioactive fission products of the wastes.

Plans also call for continuing the military programs. In the past, submarine and airplane reactor research and development, construction, and operation have made valuable contributions toward the development of civilian nuclear power, and it is reasonable to expect additional contributions from these sources in the future.

FINANCING PRIMARILY BY GOVERNMENT

The program outlined calls for financing primarily by the Government. Except for the pressurized water reactor, it consists of small, experimental reactors. All these units will produce technical and cost information which will make possible more accurate evaluation of the future of nuclear power. It is hoped that the new technology will encourage industry to take over an increasing share of the financing of further research and development and to consider with increasing

favor the actual construction of pilot or full-scale power plants. The progress of this program and the extent and growth of industrial effort will assist in determining the course of future work.

Consisting largely of small, experimental reactors, the program is designed to provide a foundation upon which future work toward industrial nuclear power can be undertaken by Government or industry. It is based on the assumption that the law will be changed to make industrial participation in reactor development more attractive.

Thus the program implements the AEC Statement of Policy on Nuclear Power Development, issued May 26, 1953, which recognized—

> * * * a responsibility of the Commission to continue research and development in this (nuclear power) field and to promote the construction of experimental reactors which appear to contribute substantially to the power reactor art and constitute useful contributions to the design of economic units.

The statement also expressed the—

> * * * conviction of the Commission that progress toward economic nuclear power can be further advanced through participation in the development program by qualified and interested groups outside the Commission.

The public hearings of the Joint Committee on Atomic Energy in the summer of 1953 brought out the fact that the cost of developing competitive nuclear power is at the present time too great for industry to carry. However, a number of industrial firms are already sharing in certain research and development projects with the AEC, and others are financing their own studies of reactor technology. Private financing thus far has been only a small fraction of total reactor development costs.

ESTIMATING NUCLEAR POWER COSTS

Economic evaluations by the Commission and its contractors show that the probability of producing electricity from nuclear fuel at a cost competitive with electricity from coal, oil, or gas is good. The estimates generally indicate that if the goal of economic nuclear power is pursued with vigor, costs can be brought down—in an established nuclear power industry—until the cost of electricity from nuclear fuel is about the same as the cost of electricity from conventional fuels, and this within a decade or two. This does not mean that such low-cost nuclear power will be obtained from the very first plants which might be built but that it may well come from succeeding plants which, as a result of experience with the first, it should be possible to construct and operate more economically.

At the same time it should be remembered that even the program outlined may not be sufficient to determine conclusively whether power can be produced cheaply enough from nuclear fuel to be of general use. There are five different types of reactors in the program, because it has not yet been learned which is the ideal or even the best choice. It will require all the ingenuity of the AEC staff, the Commission's contractors, and private industry working together to get costs down, but it is reasonable to assume that eventually this will be done.

Though the estimates which have been made are the best that can be obtained at the present time, they are merely paper evaluations and are

subject to considerable uncertainty. Architect-engineering work has not been done yet for a full-scale industrial nuclear powerplant. The estimates will become more dependable as the development program improves technology and results in more detailed plans and specifications.

Assumptions on which the costs are estimated include reasonably conventional location of nuclear plants—not location on large exclusion areas. Neither real estate prices for large exclusion areas near customers nor the cost of long distance transmission from remote areas can be borne if competitive costs are to be attained.

It is further recognized that the establishing of a nuclear power industry is dependent upon solution of a number of nontechnical problems. These include the problems of patent rights, of the lease or sale of fissionable materials, of the licensing of producers of these materials, of Government purchase of byproduct fissionable material, and accounting assumptions such as length of amortization period and amount of interest. These factors are not within the scope of the technical report.

The reactor development program will be reviewed annually in the light of accomplishment during the preceding year, and revised as necessary. Results sought in research and development cannot be guaranteed within estimated expenditure. Also, some technical avenues may turn out to be more promising, others less promising, than they now appear.

AREAS FOR COST REDUCTION

The problem of developing nuclear reactors for the economic generation of electric power is largely one of reducing costs for capital investment and fuel.

The capital cost of a nuclear plant must be reduced considerably below estimates based on current technology. The "per kilowatt cost" of a nuclear powerplant that can be built today or in the very near future will be perhaps several times the "per kilowatt cost" of a conventional plant of the same power output.

For practical nuclear powerplants of the future, a construction cost goal of $50 to $70 kilowatt of heat, roughly equivalent to about $200 per kilowatt of electricity, is sought. Then the cost of constructing a nuclear plant will be about the same as for a conventional plant.

The basic hope for making nuclear power competitive rests on the possibility of making the fuel very inexpensive—certainly bringing its cost below 3 mills per kilowatt-hour of electricity, which is about the average cost of fuel for conventional power.

To achieve this low fuel cost, technical advances sought include—

(1) Higher burnup per fuel cycle, that is, burning more fuel before it must be removed from the reactor for chemical processing. Alloying offers one possibility for reducing radiation damage so that fuel elements will last longer and withstand higher burnup.

(2) Lower cost of chemically processing and fabricating fuel elements. Partial processing without complete removal of radioactivity is attractive. Simple methods of fabricating this mildly radioactive material are being investigated.

(3) Higher thermal efficiency, that is, conversion of a larger percentage of heat energy into electrical energy. Achievement depends on higher reactor temperature. The first pioneering nuclear plants have low efficiencies—17 percent for the experimental breeder reactor No. 1 and 14 percent for the homogeneous reactor experiment No. 1. Design concepts for large water-cooled plants provide substantially higher figures, while estimates for full-scale liquid metal reactors approach 35 percent, which is approximately the efficiency of large, new conventional power plants.

In addition to reducing fuel costs, the program is aimed at developing types of reactors and modes of operation safe enough to make large exclusion areas unnecessary.

PRESSURIZED WATER REACTORS

The pressurized water reactor, a conversion from a project for a reactor for a large naval ship, will be a full-scale nuclear central station of moderate power—at least 60,000 kilowatts of electricity—and should be in operation within 3 or 4 years. It is not expected to be competitive with conventional power plants, but it will give information that can be obtained only from a large plant, such as reliability, period of amortization, and operating and maintenance costs.

This project is the next step in carrying forward the pressurized water approach to nuclear power. A number of early reactors were water cooled and this technology was advanced considerably more by the recent work of Westinghouse Electric Corp. on the submarine thermal reactor and on the large ship project.

Westinghouse is the principal contractor for the pressurized water reactor, responsible for research and development, and fabrication of the reactor itself and auxiliary equipment. The Westinghouse contract does not include the turbine and generator portions of the plant or the plant's operation. Research and development is well under way. Only slight enrichment of the uranium fuel is necessary to achieve a critical mass with ordinary (light) water moderator and coolant. Nuclear experiments are being conducted to determine the amount of uranium fuel needed, its exact enrichment, the shape of the fuel elements, and methods of fabrication. Like STR, this reactor will make use of the new metals, zirconium and hafnium, and their alloys.

Among contributions this project will make to pressurized water technology are developing and testing of fuel elements for long irradiation cycle and advancing the physics of slightly enriched uranium fuel in ordinary water. The project will demonstrate that a relatively large pressure vessel can be built according to specifications required for reactor operation. A system will be developed and demonstrated for charging and discharging compactly located fuel elements through a pressure shell. A system for the control of a reactor composed of very closely spaced fuel elements will be developed and operated.

By comparison with the submarine thermal reactor, the pressurized water reactor will operate at appreciably higher fuel temperature, coolant temperature, and steam pressure. Preliminary specifications call for a fuel temperature well over 600° F., coolant temperature

between 500° and 600°, and steam pressure of about 600 pounds per square inch. The PWR core will be about 6 feet in diameter and 7½ feet high and will require a pressure vessel about 9 feet in diameter and 28 feet high. A fuel charge will consist of 15 to 20 tons of slightly enriched uranium, that is, uranium containing 1.5 to 2 percent of the 235 isotope rather than natural uranium which contains only 0.7 percent of this isotope. A pressure of 2,000 pounds per square inch will keep the cooling water from boiling.

Other preliminary specifications include reactor power, 264,000 kilowatts of heat; maximum heat flux, 350,000 British thermal units per square foot per hour; average power density, 45 kilowatts of heat per liter; and average specific power, 1,000 kilowats of heat per kilogram of fissionable material.

EXPERIMENTAL BOILING WATER REACTOR

Some years ago use of a reactor as the direct source of steam for the turbine was suggested as an attractive way of making power. This arrangement would eliminate the need for a heat exchanger (steam boiler) outside the reactor and permit appreciable reduction in pumping power, and hence should lead to lower capital costs. However, it was thought that boiling in the core would cause continual changes in reactivity and might result in unstable operation.

In the summer of 1953, experiments with a small temporary reactor, conducted by Argonne National Laboratory at the National Reactor Testing Station in Idaho, demonstrated that these fears are not justified. It may be possible to design boiling reactors which will operate in a stable, self-regulating manner, and which in the event of trouble will shut themselves down without serious damage. These developments constitute a major contribution toward safe power reactors.

An experimental boiling water reactor of about 20,000 kilowatts of heat and 5,000 kilowatts of electricity is planned to explore further the possibilities revealed by the investigations in 1953. Specifications are being established by the Argonne Laboratory. The boiling reactor will be fueled with enriched uranium and moderated and cooled with ordinary (light) or heavy water. The uranium enrichment is necessary to make any natural uranium-light water reactor critical. Enrichment is also needed for a heavy water reactor of small size, like the EBWR, but not for a large boiling reactor.

An important purpose of the experimental boiling water reactor is to determine whether it can be operated without significant deposit of radio-activity in the turbine, the condenser, and the feed water pumps. Such deposits might cause major maintenance problems in case of equipment failure.

Assuming success with this boiling reactor, tentative specifications for a full-scale central station plant of this type have been estimated. However, EBWR is not expected to provide nuclear data on the critical mass of the large reactor or on the proper spacing of its fuel. Such information would be obtained from critical experiments.

The Atomic Energy Commission is selecting an architect-engineering contractor and a site for the facilities required for experimental boiling water reactor. The schedule calls for completion of the reactor and facilities during the latter part of calendar year 1956.

SODIUM REACTOR EXPERIMENTS

The program for advancing the technology of the sodium-cooled, graphite-moderated type of reactor centers about a preliminary design for a full-scale power plant. This design uses metallic fuel elements of either slightly enriched uranium or a combination of thorium and uranium 233.

With slightly enriched uranium fuel, the full-scale reactor is expected to have a regeneration ratio of about 0.9, producing plutonium as a byproduct. Charged with uranium 233 and thorium, the reactor should have a ratio slightly greater than one and thus operate as a power breeder, producing more uranium 233 than it consumes.

Although concepts incorporated in the full-scale design have been determined to be feasible by North American Aviation, Inc., the chief contractor developing this type of reactor, many features of the proposed plant and its operating procedure have not been tested in reactor practice. Neither are the upper limits known for fuel and coolant temperatures, burnup, and other operating variables. Moderate changes in some of these variables, such as increasing maximum uranium metal temperature from 1,200° to 1,400° F. and maximum coolant temperature from 1,000° to 1,250° F., will have appreciable effect on the cost of power.

A small sodium reactor experiment is planned to obtain information needed for evaluating the possibilities. This unit will have a heat power level of about 20,000 kilowatts, but it will not be equipped for generating electricity. The heat produced will be exhausted to the atmosphere through a relatively inexpensive sodium-to-air heat exchanger.

The sodium reactor experiment will resemble the design for a full-scale plant in important respects. For example, both designs call for tank-type reactors, both have the entire reactor structure below ground level, and both use similar fuel arrangements.

Tests possible with the SRE include fuel element performance, maximum permissible fuel element and structure temperature, and corrosion and radio-active transfer. The reactor's temperature and specific power will be increased gradually to determine performance limitations. Test "loops" circulating sodium can be installed in the SRE to determine the effect of radiation on aspects of sodium-graphite technology.

The schedule for the sodium reactor experiment calls for completion of fabrication and beginning of experimental operation in calendar year 1956.

EXPERIMENTAL BREEDER REACTOR NO. 2

Two years of operating experience with the experimental breeder reactor at the National Reactor Testing Station provides the basis for scaling up to a larger unit, called experimental breeder reactor No. 2.

The scale up planned is from 1,400 to 62,500 kilowatts in heat power output and from 170 to 15,000 kilowatts in electrical generating capacity. Fuel and coolant temperatures will be substantially higher and steam pressure will be correspondingly greater. In fact, the

temperatures and steam pressure will be the same for EBR No. 2 as are now visualized for a full-scale power-breeder reactor.

The new reactor will also be similar to a large central station unit in power density, control, and fuel-handling features. It will include pumps, heat exchangers, valves, flow meters, and other "hardware" of sizes suitable for a full-scale powerplant. In addition, as an experimental reactor, EBR No. 2 will test advanced ideas for long-range application such as variations in core and blanket concentration, in fuel-handling techniques, in power-cycle conditions, and in component design.

Operation of the first EBR, now designated No. 1, will continue to contribute to the fast-breeder research and development program valuable information on physics, radiation damage, chemical processing, and fabrication techniques. A neutron source reactor is in operation at Argonne National Laboratory to provide neutrons for reactor physics measurements on subcritical core arrangements. Results are being used to design a critical assembly for construction at the testing station in Idaho during the current calendar year. The critical assembly will provide information on such factors as critical mass, breeding ratio, and power distribution in the core.

Plans call for a mechanical mockup to be built at Argonne during fiscal year 1955 to test heat transfer and mechanical components under simulated operating conditions. Components to be tested include loading and unloading devices, control mechanism, heat exchangers, boilers, and superheaters.

EBR No. 2 probably will be loaded first with uranium 235 and later with plutonium. The blanket in each case will consist of natural or depleted uranium whose uranium 238 will be transmuted into plutonium. Because of physical constants, greater production of plutonium is expected with plutonium fuel than with uranium 235 fuel. However, the purpose of this experimental reactor is to test engineering features rather than produce a maximum amount of fissionable material.

Facilities must be built for developing, manufacturing, and processing partly used uranium and plutonium fuel elements and the irradiated uranium blanket containing plutonium.

Startup of experimental breeder reactor No. 2 is planned for calendar year 1958.

HOMOGENEOUS REACTOR EXPERIMENT NO. 2

An experimental reactor designated homogeneous reactor experiment No. 2 is to be the next major step in developing homogeneous type reactors which have their fuel and moderator in a water solution. Potential advantages of this type include low-cost chemical processing, elimination of fuel element fabrication and handling, and simplified reactor design.

The homogeneous reactor experiment, now designated No. 1, at Oak Ridge National Laboratory, has demonstrated that a 1,000-kilowatt reactor, circulating uranyl sulfate fuel solution at nearly 500° F. under 1,000 pounds per square inch pressure and at a power density of 30 kilowatts of heat per liter, will operate with stable power output. HRE No. 1 has also shown that the reactor can be operated and maintained safely after its fuel solution becomes highly radioactive from

fission products and while a mixture of hydrogen and oxygen is formed by irradiation-produced decomposition of the solution water.

HRE No. 1 will be dismantled early in calendar year 1954 and HRE No. 2 assembled in the same building. The new reactor should be in operation by the summer of 1956.

Homogeneous reactor experiment No. 2 will have a heat output of about 3,000 kilowatts as compared with 1,000 for its predecessor. Its primary purpose is to produce a simplified, mechanically reliable plant which will demonstrate operability and reliability over a long period under conditions closely simulating those of a full-scale reactor. The plant will include chemical processing equipment for the purification of the fuel solution by removal of fission products.

The homogeneous development also seeks more information on the effect of irradiation on the corrosion of materials and on the chemical stability of the fuel solution. A long series of corrosion tests without irradiation has demonstrated the compatibility at elevated temperatures of a dilute uranyl sulfate solution with a number of materials. Quantitative data of the effects of varying temperature, salt concentration, acidity, and solution velocity have also been obtained.

Corrosion and stability tests under irradiation will utilize the low intensity testing reactor at Oak Ridge and the materials testing reactor at the testing station. The equipment required for the tests includes closed "in-pile loops" of piping, pumps, and instruments which will circulate fuel solution past samples of different materials while they are under intense neutron bombardment in the test reactors.

HOMOGENEOUS THORIUM REACTOR

As the next step in developing homogeneous reactors, scale up to about 65,000 kilowatts of heat, of which about 16,000 will be converted into electricity, is planned for the homogeneous thorium reactor. This reactor is also aimed at demonstrating the production of uranium 233 from a blanket of thorium. The physical constants of the uranium isotopes and of thorium and plutonium make the generation of uranium 233 from thorium attractive for thermal reactors in which fission is primarily by slow, or thermal, neutrons, whereas the production of plutonium from uranium 238 can be accomplished most readily in a fast reactor.

Though the core of the homogeneous thorium reactor will not be as large in diameter as that of a full-scale plant, it is planned to have the same blanket thickness and concentration of thorium as a large central station reactor of this type. Two chemical plants, one for removing fission products from the fuel solution and the other for separating the uranium 233 from the thorium blanket, are contemplated as integral parts of the nuclear powerplant.

Following development and design, construction is tentatively scheduled to begin during fiscal year 1958 with completion in fiscal year 1959. The HTR probably will start operating with uranium 235, which eventually can be replaced with uranium 233 produced in the blanket.

UNITED STATES ATOMIC ENERGY COMMISSION,
Washington 25, D. C., March 12, 1954.

Hon. STERLING COLE,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR MR. COLE: Attached is the statement of Dr. Zinn's which Mr. Strauss said you had asked about.

Dr. Zinn brought the statement with him to Washington in response to a request from a member of your staff, with a view to having it declassified. The statement has been revised to permit its publication.

Sincerely yours,

K. D. NICHOLS, *General Manager.*

STATEMENT BY DR. WALTER H. ZINN CONCERNING AN EXPERIMENT USING THE BOILING REACTOR PRINCIPLE

The Argonne National Laboratory has carried out for the Atomic Energy Commission certain experiments which it is expected will have a vital bearing on the question of the safety of operation of industrial power reactors. Since safety is an important factor in the evaluation of the use of atomic energy for the generation of economically competitive electricity, it has been decided to make this information generally available. The experiments were done during the summer of 1953 at the National Reactor Testing Station, Arco, Idaho. A team of scientists and engineers from the Argonne Laboratory at Lemont, Ill., and the staff of the experimental breeder reactor project in Idaho carried out the work. Principal members of the team were S. Untermyer, J. R. Dietrich, D. C. Layman, H. V. Lichtenberger, and W. C. Lipinski, working under the laboratory director, Walter H. Zinn, as leader.

The experiment consisted of setting up and operating a nuclear reactor and then imposing conditions on the reactor which would make it "run away." This means that the power of the machine was caused to rise precipitously and was allowed to continue to rise indefinitely. Under such conditions it had been assumed in the past that the core of the reactor would melt and that this would permit the escape of radio-active fission products. It is this particular assumed circumstance which has governed decisions concerning locations of nuclear reactors and which has required an uninhabited, restricted area surrounding them of an acreage which is determined by the power of operation. This particular reactor was moderated by water and cooled by water. The experiment showed that power excursions of very large magnitude and which took place quite rapidly did not produce melting of the fuel and no radioactive contamination of the surroundings whatsoever resulted. The favorable effects observed were anticipated and are due to the particular design of the reactor,

which is so arranged that the formation of steam quenches the nuclear reaction. In experiments in which the power was allowed to rise to many thousand watts in a fraction of a second, the steam formation process nevertheless quenched the nuclear reaction completely long before a dangerous temperature was induced.

The experiments were carried out in such a way that visual evidence of the formation of steam and the motion of water was obtained. The most vigorous tests to which the reactor was subjected involved conditions which it would be hard to imagine occurring in any combination of accidental events in an operating power reactor. The visual results were quite spectacular.

It is believed that this mechanism if applied to the design of power reactors may constitute an inherent safety mechanism which will make it impossible for the nuclear reaction, itself, to create dangerously high temperatures. The experiment is an example of the way in which research and development can contribute to the solution of the safety problem. Design and experimentation can be expected to show that there are other types of reactors for which safety is not a major problem.

The reactor also was operated successfully under conditions in which steam was continuously formed and ejected from the reactor. This suggests that it may be possible to construct powerplants in which the reactor not only releases heat but converts it to steam for use in a turbine. In some designs of water-cooled power reactors, the heat is released to water which is circulated to a boiler where steam is produced for use in a turbine. Economies might result from the elimination of the boiler and the production of steam directly from the reactor. This possibility requires further exploration and such work is being undertaken by the Argonne National Laboratory.

MARCH 5, 1954.

APPENDIX

APPENDIX A

The Development of Nuclear Power for Peaceful Purposes

Remarks prepared by Henry D. Smyth, member, United States Atomic Energy Commission, for delivery at the national meeting of the American Institute of Chemical Engineers, Washington, D. C., March 9, 1954

I. Introduction

The structure of modern industrial society depends on plentiful supplies of energy. There is never enough. We are always seeking new sources. Yet, we have not tapped the most generous sources of energy that nature has supplied to us—the winds, the tides, the rays of the sun. We have not yet learned how to harness these great natural forces.

Fifteen years ago a new natural force was discovered, the fission of uranium. Within the first 2 months of 1939 the idea of uranium fission was suggested, communicated, proved experimentally, and published. The speed and importance of this discovery constitute one of the most spectacular events in the history of science. It involved men of many nations, free communication, high imagination, and precise experiment.

In a world at war, the potential use of nuclear fission in bombs meant that vast sums of money were soon available for its exploitation. In 1945, only 6 years later, an atomic bomb marked the end of the Second World War.

We are now engaged in an effort to harness this same atomic energy for peaceful purposes. It is a great effort and, indeed, should be so, for success in it may materially change the lives and conditions of men. The accident of history has placed the major responsibility for this effort on the Government of the United States. As its agent, the Atomic Energy Commission has brought together an array of scientific and engineering talent never before equaled. Private industry already is carrying a major share of our enterprise under contract to the Government and is now becoming more and more active on its own initiative. This is as it should be.

Those of us engaged in this effort believe we shall be successful. We are so confident of success that we do not begrudge the years and the skill and the millions of dollars that are being spent to make available to man the kind of energy that heats the stars. But the road to success will be a long one. We know that it will have many dead ends and wrong turnings and many dull and dreary stretches. The barriers to be surmounted or bypassed are formidable.

By now we think we know what these barriers are, what kinds of problems have to be solved if nuclear power is to be significant in our economy. We should know these problems, for it is now 15 years since nuclear fission was discovered, 10 years since the first large-scale nuclear reactor was started, and 5 years since the Atomic Energy Commission announced its first program of nuclear reactors aimed at power. Energy from nuclear powerplants will be just like energy from coal-burning powerplants. Except for special purposes, the sole criterion of comparison will be cost.

Let me outline the problems we foresee. It is from men like you that their solutions will come. The problems of reactor development today are best explained in terms of those which faced the designers of the first great reactors at Hanford. These problems are so fundamental that they will continue to be of major importance even though the emphasis may shift from time to time. Once I have defined the problems, I shall outline our present state of knowledge and the next major steps we are planning for their solution.

II. THE GENERAL PROBLEMS OF A NUCLEAR POWER REACTOR

Let me recall to you the three major facts of nuclear fission. They are; first, that enormous amounts of energy are released; second, that the products of fission are radioactive; and third, that fission is caused by neutrons and results in the production of further neutrons thereby making a chain reaction possible.

These basic facts confront the designers of reactors with a series of technical questions which can be grouped in five general areas. These general areas which have to be considered are, first of all, what we call neutron economy; second, the effects of nuclear radiations; third, heat transfer or removal; fourth, control and instrumentation; and fifth, chemical processing of fuel both before and after it goes into the reactor. Let me go into some detail about these five areas.

1. Neutron economy

It is evident that the first requirement of a nuclear reactor is that the nuclear chain reaction shall occur. In other words, if a uranium nucleus in a structure containing uranium does undergo fission, it must produce neutrons in sufficient quantity to cause other nuclear fissions in the vicinity and to set up a self-propagating nuclear chain reaction. Actually the number of neutrons produced by a single fission is not very large. On the average, for every neutron used up in producing a fission about two and a half new neutrons are released, a net gain of one and a half neutrons per fission. At first sight, this would appear plenty to produce a multiplication of fissions. Unfortunately, from the point of view of neutron economy, all the neutrons produced in a single fission are not absorbed in uranium 235 to produce additional fissions.

There are, in fact, four things that can happen to the neutrons that are produced in the fission process. First of all, since neutrons are extremely penetrating, they may simply escape to the outside environment. A second way in which they disappear is by capture by uranium 238 without causing fission. A third possibility is that they may be captured by impurities in the uranium or by the structural materials that have to be introduced for cooling or other purposes. The fourth possible process that can occur is, of course, the capture of neutrons by uranium 235 resulting in fission. If the fourth process produces more neutrons than are lost by the first three processes, the chain reaction occurs. Otherwise, it does not. Evidently, in a given arrangement the first three processes may have such a high probability that the extra neutrons created by fission will be insufficient to keep the reaction going.

One obvious way to reduce the probability of the escape of neutrons is to increase the amount of uranium present. The more uranium there is, the more likely it is that the neutrons will be absorbed in it and cause fission rather than escape. This leads, of course, to the concept of critical mass which is familiar to many of you and which I will not discuss any further.

The second process we need to minimize is the capture of neutrons by uranium without producing fission. There are several things that can be done to minimize this process. Two of them depend on the great effect which the speed of the neutrons has on the probability of their absorption in uranium 238. This probability is reduced by using a slowing down material, called a moderator, and arranging the uranium in a lattice. Another way to reduce nonfission capture by uranium is to eliminate part or all of the uranium 238 isotope, since it contributes very little to the fission process and does absorb many neutrons. Of course, in the Hanford reactors, this was not desirable because one of the objectives of the Hanford reactors was to produce plutonium by absorption of neutrons in uranium 238.

To reduce the third process, the nonfission capture of neutrons by impurities or structural materials requires that the uranium itself be very highly purified in the first place and that structural materials be used which have a low capacity for the absorption of neutrons. This last consideration puts many restrictions in the path of the designer of a nuclear chain reactor.

2. The effects of nuclear radiation

The effects of nuclear radiation have several aspects that the designer needs to keep in mind. Perhaps the most important one technically is the fact that the constant bombardment of structural materials and of uranium itself causes changes in their properties. A piece of uranium, a piece of steel or aluminum in a nuclear reactor is continually bombarded by neutrons, by gamma radiation, and to some extent by other nuclear radiations. The result of such bombardment may be a change of shape, an embrittlement, a change in thermal conductivity, or

of almost any other property of the material. The rate of corrosion of a material is affected by the presence of nuclear radiation.

Nuclear radiation is dangerous to health. Consequently, the whole reactor structure must be surrounded by a shield which will not be penetrated by the neutrons and other radiation. Radiation is present not only while the reactor is running, but induces a lasting radioactivity in the materials of the reactor. In particular, fuel elements in the reactor become highly radioactive, and when they are unloaded for chemical processing, they have to be handled by remote control. It is unsafe for any personnel to handle them directly. Similarly, maintenance must be held to an absolute minimum, and actual direct access of the operators to the heart of the reactor must be avoided.

3. Heat transfer or removal

The principal interest in establishing a nuclear reaction is because the fission processes release such enormous amounts of energy, millions of times the amounts of energy released in chemical reactions in corresponding amounts of material. To be sure, the Hanford reactors were not designed for the purpose of producing energy but for the purpose of producing plutonium. Nevertheless, the production of large amounts of energy is inescapably associated with the fission process, and therefore, the designers of the Hanford reactors had to provide some means of removing that energy. It was a simpler problem for them than for the designers of a reactor intended to produce energy. The Hanford designers had merely to get rid of the energy in some way.

The designers of a power reactor must extract the energy in a form which can be put to use. Nevertheless, many of the problems are the same. They differ from ordinary heat transfer problems for reasons that have already been suggested; namely, that the choice of materials is limited by neutron economy, that corrosion effects may be enhanced by the radiation present, and finally that the replacement of parts is difficult or impossible because of the health dangers involved. In a power-producing reactor, the temperature should be as high as possible so that the heat energy removed can be converted into useful power efficiently. This is a real difficulty as we shall see later on and is one point where the Hanford designers had a considerable advantage.

4. Control

When the first reactors were designed, the question of control was a very critical one. No one knew very certainly whether or not it would be possible to prevent the reactor from running away with itself. We do not want to have a reactor heat up to the point where it will melt and destroy itself. We wish to avoid this for two reasons: First, we don't want to lose the reactor; and second, we don't want to spew radioactive material all over the countryside. By now, we have had enough experience so that we are not very concerned about essential difficulties of control. We are perfectly sure that we can build a reactor which we can control. In fact, as I shall mention later, some types of reactor are self-controlling. There does remain, however, a problem of convenience, efficiency, and cost in designing the proper controls to start, stop, or maintain at a desired operating level the nuclear chain reaction.

5. Chemical processing of fuel

Ideally, we would like to put into a nuclear reactor a certain amount of uranium and leave it there until all the uranium had been converted into heat energy and fission products. If that were possible, we would be concerned with chemical processing only in preparing the fuel. Unfortunately, the difficulties both of neutron economy as affected by the growth of fission products and of the corrosion or radiation damage of structural materials or fuel elements make it quite out of the question to consume more than a fraction of a nuclear charge in any know design of reactor. After a certain length of time—and one of the problems in the design of reactors is to make that length of time as great as possible—it is necessary to remove the fuel. It is too valuable to throw away, since it will probably still contain some 90 percent or more of the fissionable material. Consequently, we have to reprocess it chemically, separating out the fission products, and refabricating the uranium into new fuel elements. This turns out to be one of the most costly processes in the whole business of operating a reactor for power.

I believe it is possible that the nuclear power industry will stand or fall economically depending on the success which chemists and chemical engineers have in developing cheap processes for purifying and refabricating nuclear fuel.

III. THE HANFORD REACTORS

I have been speaking of the general technical problems of reactor design. To be more concrete, let me recall briefly in specific terms how these problems are met in the Hanford reactors.

For neutron economy, the reactor is large. It uses graphite as a moderator, and the natural uranium fuel elements are arranged in a lattice. Both graphite and uranium are very highly purified. Cooling channels and protecting coatings of the uranium fuel elements are aluminum of minimum dimensions.

To shield operating personnel, the reactor is surrounded by heavy composite walls and all control and operation are from outside the shields. To reduce corrosion of the aluminum, the cooling water is purified and the temperatures held relatively low. To avoid corrosion or distortion of the uranium, it is canned in aluminum and not left in the reactor very long.

Heat is removed by large volumes of Columbia River water with relatively low exit temperature. The water is then held in retention basins before returning to the river.

Control is by neutron absorbing rods that move in and out of the reactor. The position of the rods is recorded at the control desk and varied by the operators or automatically in response to instruments.

Chemical procesing by a solvent extraction process is done in a separate plant to which the fuel elements are transported in shielded railroad cars, with all operations remotely controlled.

Fundamentally, it is the low exit temperature of the cooling water and the short life of the fuel elements that make this plant impracticable as a power source.

IV. BREEDING

Uranium 235 is the isotope of uranium in which fission occurs most readily. Unfortunately, it is present in natural uranium only 1 part to 140. Natural uranium is none too plentiful, and to be able to use only seven-tenths of a percent of it is frustrating. Neutrons absorbed in the other uranium isotope, uranium 238, lead to the production of plutonium and plutonium is readily fissionable. This fact early suggested the possibility that a reactor could simultaneously produce heat energy from the uranium 235 in natural uranium, and produce plutonium from the uranium 238, and that then the plutonium could be used as fuel for further production of energy. It was even suggested that the plutonium produced might be greater in quantity than the uranium 235 burned up. Such a process is called a breeding process since more fuel can be produced than would be burned.

This is, of course, a very fascinating idea. It turns out, however, that it may not be so very important whether actually more material is produced than is burned. It is obviously possible to produce some plutonium, since that is what the Hanford reactors are for and it should be possible to take that plutonium and use it as fuel for power reactors. Whether the amount of plutonium produced is slightly less or slightly greater than the amount of uranium 235 burned up is not very important. We do, however, make a distinction in nomenclature whereby we call a reactor that produces plutonium in smaller quantity than uranium burned a converter and one where the quantity produced is greater than that of uranium burned a breeder. In either case, it should be possible eventualy to convert the fission energy of both isotopes of uranium to useful power. In the case of the converter, there would be some loss; in the case of the breeder, the losses in the reactor would be zero, but in either case, there will be losses in chemical processing so that the difference is not very significant. The difference, however, between using just the uranium 235 and evenutally using all of the uranium in natural uranium is enormous and may well make the difference between an ample supply of nuclear fuel for many years to come and a rather scanty one.

V. THE FIRST ATOMIC ENERGY COMMISSION REACTOR PROGRAM

When the Atomic Energy Commission took over the plant and equipment of the Manhattan District in January 1947, the problems that I have been reviewing were already clear. Although the Commission's first responsibility was to prosecute the atomic weapons program with vigor, it soon turned to the possibility of atomic power, both for special military purposes and for ultimate peacetime uses. Early in 1949, Dr. Bacher, my predecessor as the scientific

member of the Commission, made a speech in which he outlined the ways in which the Commission was attacking the problems I have reviewed. Essentially, the program consisted of a plan to build four major reactors. Let me describe three of these that have been finished at our Idaho test site and why they were built.

The first of them was the so-called materials testing reactor, MTR. It was aimed primarily at getting information on the effects of radiation on uranium fuel elements or other materials that might be used as tubes for cooling water, or as coolants, or containers for uranium fuel elements. The object of this reactor then was to provide very high intensity radiation in a machine so designed that many experimental samples could be placed in it. It has now been running for about 2 years, and it has in fact proved exceedingly useful. Incidentally, it also was a novel kind of reactor and therefore was in itself a step toward the development of new types of reactors.

The second reactor built at Idaho was the so-called experimental breeder reactor, EBR. As the name implies, it was specifically aimed at demonstrating whether or not breeding was possible. It has demonstrated that breeding is possible and has had a number of other incidental interesting results.

The third reactor was a special purpose one aimed at providing power for a submarine. You have heard a great deal about that one and about the submarine in which a similar reactor is now being installed.

In all three of these reactors, the neutron economy problem was solved by using uranium from which much of the uranium 238 isotope has been extracted. Whether or not in the long run, this is the kind of reactor we will build for power purposes will be largely a question of economics. Personally, I doubt it, but I do not doubt the wisdom of having built these three reactors and the value of the results we have obtained from them.

A more modest undertaking initiated later is the homogeneous reactors experiment at Oak Ridge. From the atomic point of view, the homogeneous reactor is misnamed. In reality, one can think of it as a lattice where the spacing is very small and the size of the fuel elements is of atomic dimension. To put it more simply, and in terms that will be more familiar to you, the homogeneous reactor is a solution of uranyl sulphate in water. The water serves as the moderator, and the uranyl sulphate molecules serve as the fuel elements in which the chain reaction is set up.

The immediate and obvious advantage of the homogeneous reactor is that fuel fabrication and processing is enormously simplified. The solution is pumped continuously through the reactor chamber and then cooled in outside heat exchangers, and some of it can be continually led off for purification and then reintroduced into the circulating stream of combined fuel and moderator. One of the interesting features of the homogeneous reactor is that it turns out to be self-regulating. As the temperature of the reactor rises, its reactivity decreases and therefore it controls itself. One difficulty that was anticipated in the homogeneous reactor was that the water itself would be dissociated by the radiation. This does occur, but it has been found possible to recombine the hydrogen and oxygen formed without too great difficulty.

In addition to the results obtained with the 3 reactors I have been discussing, and the homogeneous reactor experiment, there has, of course, been an extensive program of study of the various associated problems in the laboratory. These range from fundamental studies of what causes radiation damage, or of the absorption probabilities of various materials for neutrons of various energies, to component testing in heat loops, and experimental fabrication of fuel elements. Some of these studies use the various low-power research reactors that have been built.

One of the most interesting experiments that has been done was carried out last summer at the Idaho test site by Dr. Zinn, director of our Argonne Laboratory, and his associates. We had long worried about what would happen to a water-cooled reactor if the flow of water should be cut off. We were afraid if the water supply was cut off or if the temperature of the reactor rose too rapidly boiling would occur and that this might have disastrous results. Dr. Zinn decided to make a direct approach to this problem and built a small reactor with the deliberate intention of producing boiling. When it was set up at the Idaho testing station, it had an arrangement in it which suddenly ejected the control rods so that the power generated by the chain reaction went up in a fraction of a second from a few watts to many thousands of watts. This had the expected effect on the water. It boiled. It boiled so violently in fact that it was ejected from the reactor in a small geyser. Repeated trials showed that in every case

the boiling reduced the power of the reactor so rapidly that no serious damage was done.

This particular experiment illustrates very well the reasons for choosing an isolated area as a site for experimental reactors. It was not only that some of the reactors might be inherently dangerous, but it was felt that an experimental reactor, one built primarily for the purpose of obtaining information, should be operated to extremes, and that it was desirable to have them in an isolated location for that reason. In other words, if you want to get as much information as you can out of a reactor, you need to push it to the point where it might conceivably run into trouble.

VI. RESULTS OF THE PAST FIVE YEARS AND PRESENT STATUS OF THE ART

Let me summarize some of the major results that we have obtained in the last 5 years either directly from the reactors we have built and operated or from laboratory work. I will take them in terms of the 5 general areas that I enumerated at the start. So far as neutron economy is concerned we have learned a great deal about the probabilities of various nuclear events, including the relationship between the probability of fission and the energy of the neutrons. (This, for example, was tested in the experimental breeder reactor.) We have found that we can use a number of different substances as moderators, specifically beryllium, light water, and heavy water in addition to the familiar graphite.

As to the effects of radiation, the MTR has, of course, been of the greatest value as one might expect since it was designed for that purpose. But we also have the benefit of studying the fuel elements that have been in the EBR and in the submarine thermal reactor. "These," too, have been valuable. We have made a great variety of alloys and have tested various fuel elements. In particular, the submarine thermal reactor has shown that fuel elements sheathed in zirconium will resist corrosion and radiation effects over considerable lengths of time and represent a great improvement over the aluminum sheathed fuel elements in the Hanford reactors. Radiation effects have also been studied in a variety of coolants including sodium and heavy water.

In the matter of heat transfer we have found we can remove the heat from a reactor by circulating molten sodium-potassium alloy through it. This is the system of heat removal used in the EBR. We have also done a great deal of work on pure sodium as a possible coolant and are using it in the second type of submarine reactor now under construction. We have also found that we can use a cooling system of pressurized water. This is the system used in the submarine thermal reactor. We have run reactors at much higher temperatures than we were ever able to run them at Hanford, and therefore, we have moved in the direction of efficient use of the energy from nuclear fission.

As to control and instrumentation, the most striking results have been those already mentioned where we have found that certain types of reactors are in fact self-regulating as a result of boiling or near boiling as the temperature rises. The only other result I will mention is the use of hafnium as a material for control rods. Hafnium is present as an impurity in zirconium and has to be removed before zirconium cladding can be used for fuel elements because it absorbs neutrons. For the same reason it is very useful as a control material.

In the matter of chemical processing, perhaps it is fair to say that most of the work has been accomplished in the laboratory, although we have had experience with actual processing of the various types of fuel elements in the new reactors, none of which is exactly like those at Hanford. We have also proved that the homogeneous reactor will work, at least on a small scale, and we, therefore, know that that is one direction in which to hope for improvement.

In the matter of costs, we still have much work to do. None of the reactors that we have actually put up is cheap, either to build or to operate. The submarine thermal reactor probably costs somewhere around fifteen hundred or two thousand dollars per kilowatt to build, which is to be compared with the cost of a modern steam plant somewhere around a hundred and eighty dollars per kilowatt. But the submarine thermal reactor does prove one overall major result: namely, that it is possible to build a reactor for the production of power that will run for at least reasonably long times continuously and efficiently.

VII. QUESTIONS STILL TO BE ANSWERED

The fundamental question still to be answered is whether a power producing uranium reactor can be built which will compete with other sources of energy. The answer to that question will be found in the choice of some one of the kinds

of reactors we have already built or thought about. None of them has yet been proved to be the ideal or even the best choice. The homogeneous reactor, for example, does simplify chemical processing, but it requires enriched fuel and it is not yet certain that the corrosion problems can be solved. The breeder has not yet been proved on any large scale so that we do not know at all how expensive that may be. The submarine thermal reactor uses such expensive materials for cladding the fuel elements that it is almost certainly not competitive, even though we may be able to produce zirconium at lower and lower costs. It also uses enriched material. And so it goes all through the list.

VIII. PROPOSED 5-YEAR PROGRAM

In the last few months we have been reviewing the results that we have obtained up to the present time and planning what would be best to do over the next few years in order to arrive at an economical solution of the problem of nuclear power. We have decided that there are six programs that we should pursue. One of these is the general program that we must obviously continue, the program of research on fundamental properties of materials, on nuclear reactions, on components that might go into the reactors of the future, and on chemical processes. This work will be continued principally in our Argonne and Oak Ridge Laboratories. In addition to this general research and development work, we wish to build five reactors of varying size and cost. The Commission has recently submitted to the Joint Committee on Atomic Energy a special report on the reactor program prepared at the request of the committee.

The first of these reactors in our new program has already been publicly announced. It is the so-called PWR reactor which is designed to generate at least 60,000 kilowatts of electric power. It will use slightly enriched uranium as fuel, ordinary water as a moderator and coolant. The reactor will be operated under reasonably high pressure and temperature, not nearly so high as are used in modern steam plants, but as high as we feel safe in terms of our present knowledge. Specifically, the water in the reactor will be under 2,000 pounds per square inch pressure and at a temperature between 500° and 600° Fahrenheit. Steam will be delivered to the turbine at about 600 pounds per square inch. The temperature is limited by the corrosion of the fuel elements and piping and container, and the pressure is limited by the strength and size of the vessel in which the reactor must be contained. One of the difficult problems in this reactor will be that of getting control mechanisms to operate in a high-pressure vessel. Principally, we hope to learn from this reactor how such a plant may stand up under ordinary operating conditions of central-station electric powerplant, and how much it costs to build and operate it. We have no expectation that this reactor will produce power as cheaply as a modern coal-burning plant, but we hope to learn how costs can be cut in later plants.

The second new reactor which we wish to build is a breeder of intermediate size. It will not be of direct interest from the point of view of economic power, but it will be much larger and more nearly a power producing, continuously operating reactor than the small experiment we have been running out in Idaho. The scaleup planned is from 1,400 to 62,500 kilowatts of heat, and from 140 to 15,000 kilowatts of electric power. Temperatures and steam pressure will be increased to values appropriate to a full-scale power-breeder reactor. Auxiliaries such as pumps, heat exchangers, valves, etc., will be of sizes suitable to a full-scale reactor.

Our third step is based on the boiling experiment that I have already described. It will be an attempt on an intermediate scale actually to use boiling of the water as a method of heat extraction. We hope in this way to get a very cheap method of getting the heat out of the reactor and possibly of eliminating one step between the coolant in the reactor and the turbines which turn the generator. It is planned to feed the steam generated in the reactor directly to the turbines. Present plans call for 20,000 kilowatts of heat and 5,000 kilowatts of electric power.

The fourth reactor which we intend to build is a larger version of the homogeneous reactor. Again, it will be a step in the direction of a practical power-producing unit and should give us information about corrosion, chemical processing, and operating conditions that cannot be obtained with the small machine now in use at Oak Ridge. Present specifications call for only 3,000 kilowatts of heat in this reactor experiment compared to 1,000 in the present experiment. The next step, already planned, calls for 65,000 kilowatts of heat in a homogeneous reactor which will breed uranium 233 in a blanket of thorium surrounding the chain-reacting core.

The fifth reactor experiment which we plan to build is a little different from any that I have described. I have mentioned that the breeder reactor uses sodium-potassium alloy as a coolant. You all know that the Hanford reactors use graphite as a moderator. We hope to be able to combine these two materials, getting the advantage of high temperature without high pressure from the sodium coolant. To test this combination, we will build a reactor generating about 20,000 kilowatts of heat but without any electric-generating plant attached.

In addition to these new proposals, we shall continue several other programs already underway. These include the so-called intermediate submarine reactor now under construction at West Milton, N. Y., near Schenectady, and the development of a reactor to propel aircraft. Though the aims of both of these projects are special, they will undoubtedly contribute to the general technology.

IX. COSTS

It is evident that we can build powerplants which will convert the energy release in nuclear fission into electrical energy to be fed into transmission lines. The question that has not been answered and may not be conclusively answered even by the program I have outlined is whether this power can be produced cheaply enough to be of general use. The Atomic Energy Commission believes that it can be done and this is the opinion also of the several private industrial groups who have been studying the problem for several years at the invitation of the Commission. At present, the power delivered by the submarine reactor at our Idaho plant costs about 10 times as much as it would if we bought it from the Idaho Power Co. From this figure you can see that it will require all the ingenuity of our staff, our contractors, and private industry working together to get costs down, but it is reasonable to assume that eventually this will be done.

X. INDUSTRIAL PARTICIPATION

These private industrial groups I have mentioned are interested in more than just cost studies. They have assigned able members of their staffs to design studies of nuclear powerplants and in some cases are doing considerable amounts of research at their own expense. But it is a mistake to think that private industry can or will pick up the burden of development of nuclear powerplants in the present state of the art. It is a field in which knowledge and competence are still largely confined to Government laboratories and in which the financial risks are still too great for private industry to carry alone.

The Commission hopes for greater and greater participation by industry both technically and financially and for a gradual transfer of the nuclear power part of the Commission's responsibilities to private enterprise. To discuss the many problems of such a transfer would need another speech. Personally, I feel they are just about as difficult as the technical problems of getting cheap nuclear power. Time, money, and thought will be needed for both sets of problems. I believe they can be solved.

XI. CONCLUSION

To establish a nuclear power industry in this country will be a great achievement. If power becomes cheaper and more plentiful, our material standard of living will be raised. In other countries the effect may be even greater. By the accident of history the first use of this great new discovery has been in the development of weapons of war, weapons of appalling magnitude. The nations of the world have today the means to destroy each other. They also have, in this same nuclear energy, a new resource which could be used to lift the heavy burdens of hunger and poverty that keep masses of men in bondage to ignorance and fear. Toward this peaceful development of nuclear power we have, all of us, a high obligation to work with all the ingenuity and purpose we possess.

APPENDIX B

[Atomic Energy Commission press release, March 14, 1954.]

AEC AND DUQUESNE LIGHT CO. TO NEGOTIATE ON ATOMIC POWER PLANT

Lewis L. Strauss, Chairman of the Atomic Energy Commission, announced today that a proposal submitted for participation by the Duquesne Light Co. of

Pittsburgh, Pa., in the construction and operation of the Nation's first full-scale central station nuclear power plant is the most favorable to the Government and that the AEC is negotiating a formal agreement with the company. The Duquesne Co. submitted 1 of 9 major proposals to the Commission.

Under the Duquesne proposal the company would—

1. Furnish a site for the entire project and build and operate a new electric generating plant at no cost to the Government.

2. Operate the reactor part of the plant and bear the labor costs thus entailed.

3. Assume $5 million of the cost of research, development, and construction of the reactor portion of the plant.

4. Pay the Commission at the rate of 48.3 cents per million B. t. u.'s of steam used in the turbines for first year; the rate increasing annually until it reaches 60.3 cents in the fifth year.

5. Waive any reimbursement by the Government of costs incident to termination of the contract.

The Chairman estimated that, including revenues from the sale of steam generated by the reactor, the company's proposal would reduce by an estimated $30 million the expenditures the Government would have to make during the period of construction and 5 years of operations if it undertook the full cost of the project.

The proposed plant site is on land presently owned by the company in the greater Pittsburgh area. The reactor design will incorporate safety features developed through 10 years of experience with reactor operation.

The Westinghouse Electric Corp. has a contract with AEC to develop, design, and construct the reactor portion of the plant. The reactor is expected to generate sufficient heat to produce a minimum of 60,000 kilowatts of salable electricity in addition to meeting the electricity requirements of the plant itself. The actual capacity of the reactor may turn out to be somewhat greater than the minimum of 60,000 kilowatts design and foreseeing this possibility the company would design its generating plant with some reserve capacity.

It is not expected that this first plant will produce electric power at costs competitive with power from conventional fuels. The project has been undertaken, in order to gain more design and technological experience than could be obtained otherwise, such as from a smaller plant, and to provide firm cost estimates for the future.

This type of reactor, known as the pressurized water reactor (PWR), will be cooled and moderated by ordinary water under pressure. The fuel will be slightly enriched uranium, that is, it will have a slightly greater concentration of uranium 235 than occurs in nature. This type of reactor was selected because research and development on it is more advanced than on other types. Several early reactors were water cooled and this technology also was advanced to a very great extent by the work of Westinghouse on the submarine thermal reactor developed to power the submarine *Nautilus* and on the large naval vessel reactor project.

The Duquesne Light Co. supplies electric power to the greater Pittsburgh district, one of the world's largest industrial centers. Since last October the company has engaged in nuclear power reactor studies under the AEC's industrial participation program. Preceding its entry into this study, the company arranged to have some 40 of its engineers attend a special course on atomic energy at the Carnegie Institute of Technology.

In announcing the negotiations with Duquesne for participation in the PWR project, Mr. Strauss pointed out that this project represents only one of several approaches to the development of technology and equipment for economical electric power production from atomic reactors. He called attention to the announcement by Dr. Henry D. Smyth, member of the Commission, in an address March 9 to the American Institute of Chemical Engineers, of other approaches which the Commission has concluded should be undertaken, including breeder, boiling water, homogeneous, and sodium-graphite reactor projects.

○

DOCUMENTS EXPEDITING PROJECT

DEFENSE MOBILIZATION ORGANIZATION

COMPILED BY THE

JOINT COMMITTEE ON DEFENSE PRODUCTION

(This pamphlet supersedes the Defense Mobilization Organization Chart, August 12, 1952)

May 15, 1954

JOINT COMMITTEE ON DEFENSE PRODUCTION

(Created Pursuant to Public Law 774, 81st Congress)

To make a continuous study of the programs authorized by the Defense Production Act of 1950 (Public Law 774, 81st Congress, approved September 8, 1950), and to review the progress achieved in the execution and administration of such programs

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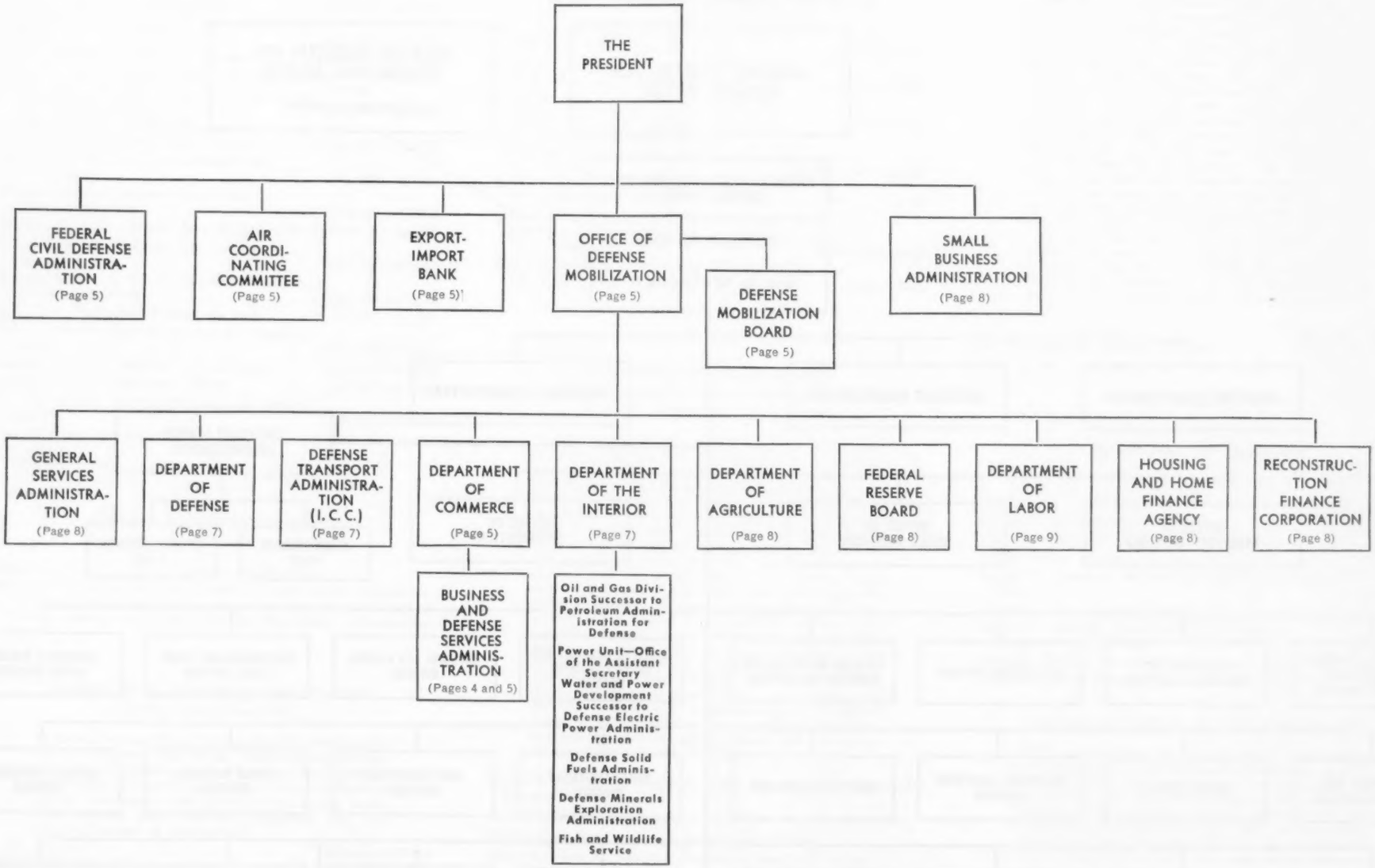
CHAIN OF COMMAND


THE PRESIDENT
FEDERAL CIVIL DEFENSE ADMINISTRATION (Page 5)
AIR COORDINATING COMMITTEE (Page 5)
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OFFICE OF DEFENSE MOBILIZATION (Page 5)
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Oil and Gas Division Successor to Petroleum Administration for Defense
Power Unit—Office of the Assistant Secretary Water and Power Development Successor to Defense Electric Power Administration
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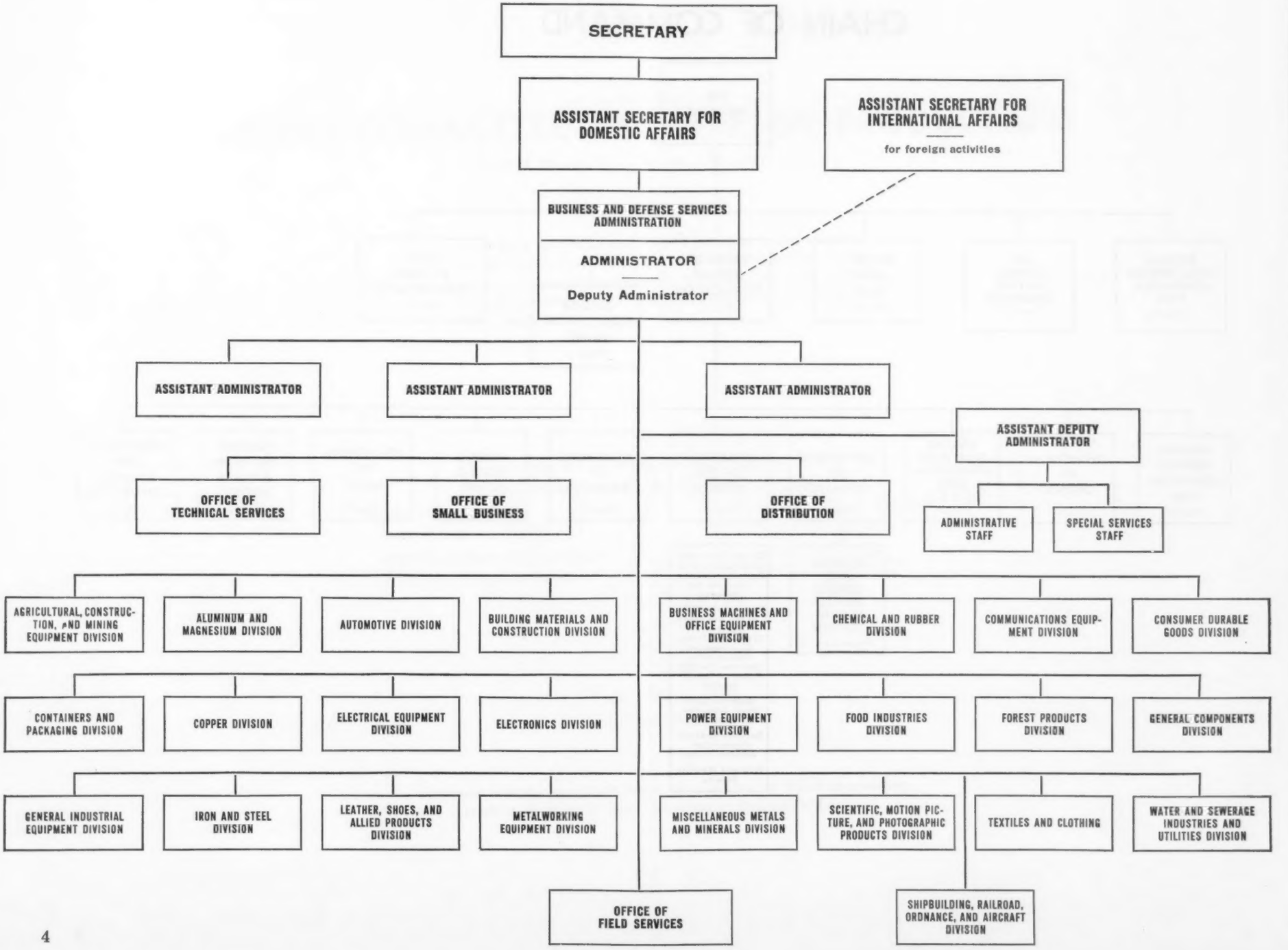
U. S. DEPARTMENT OF COMMERCE

BUSINESS AND DEFENSE SERVICES ADMINISTRATION



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Members: Secretaries of State, Treasury, Defense, Interior, Agriculture, Commerce, and Labor; Chairman, Board of Governors of the Federal Reserve System; and Director, Foreign Operations Administration.

FEDERAL CIVIL DEFENSE ADMINISTRATION

(1930 Columbia Road NW.)

To provide a plan of civil defense for the protection of life and property from attack. Responsibility for civil defense rests primarily in the States and their political subdivisions; the Federal Government through FCDA shall provide coordination and guidance and certain funds. (Not created under Defense Production Act, but included because of relationship.)

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Wilbur B. Pettigrew, *Acting Regional Administrator*, 108 North Ottawa Street, Joliet, Ill.	Joliet 6–6168

AIR COORDINATING COMMITTEE

(Department of Commerce Building)

(STerling 3–9200 or Code 164, ext 3613)

Pursuant to Executive Order, the Committee provides for the fullest development and coordination of aviation policies and activities of the Federal agencies and in the interest of the internal management of the Government. The Committee examines aviation problems and developments affecting more than one participating agency; develops and recommends integrated policies to be carried out and actions to be taken by the participating agencies or by any other Government agency charged with the responsibility in the aviation field; and, to the extent permitted by law, coordinates the aviation activities of such agencies except activities relating to the exercise of quasi-judicial functions. The Committee submits to the President such recommendations on aviation policies as require his attention by reason of their character or importance. The Air Coordinating Committee provides close liaison between governmental and private activities in the aviation field and also consults with representatives of the United States to the International Civil Aviation Organization and with Federal interagency boards and committees concerned with aviation activities.

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(811 Vermont Avenue NW.)

Pursuant to section 302 of the Defense Production Act of 1950, as amended, section 311 of Executive Order No. 10480 of August 14, 1953, authorized and directed the Export-Import Bank to make loans (including participations in, or guarantees of, loans) to private business enterprises, for the expansion of capacity, the development of technological processes, and the production of essential materials, including the exploration, development, and mining of strategic and critical metals and minerals, in those cases where such expansion, development, or production is carried on in foreign countries. Such loans shall be made, within such amounts of funds as may be made available pursuant to the Defense Production Act of 1950, as amended, (1) upon such terms and conditions as the Bank shall determine, (2) only after the Bank has determined in each instance that financial assistance is not available on reasonable terms from private sources, and that the loan involved cannot be made under the provisions of and from funds available to the Bank under the Export-Import Bank Act of 1945, as amended, and (3) only upon certificate of essentiality of the loan, which certificate may be made by the Director of the Office of Defense Mobilization or the Administrator of General Services. Applications for such loans are received directly from applicants by the Bank.

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(14th between Constitution Avenue and E Street NW.)

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Business and Defense Services Administration

BDSA exercises the authority delegated to the Secretary of Commerce under the Defense Production Act of 1950, as amended, with respect to priorities and allocations of materials and production in support of military and atomic energy programs, and participates in the Government's overall industrial preparedness programs under the general direction of the Office of Defense Mobilization. It develops and promotes measures for the expansion of productive capacity, and for production and supply of materials and facilities necessary for defense and for maintaining a strong national economy. (BDSA was established on October 1, 1953, as the successor to the National Production Authority. It is part of the Department of Commerce, but is listed here for convenience.)

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50 7th St. NE.
Merrill C. Lofton, *Manager*
(Phone: Elgin 3311)

Charleston 4, S. C.
Area 2
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West End Broad St.
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(Phone: 2–7771)

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William T. Hunt, *Manager*
(Phone: Woodward 3–9330)

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607 Marquette Ave.
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717 Liberty Ave.
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520 SW. Morrison St.
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Ben Maffi, *Manager*
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870 Market St.
John J. Judge, *Manager*
(Phone: Yukon 6–3111)

Seattle 4, Wash.
805 Federal Office Bldg.
909 First Ave.
Philip M. Crawford, *Manager*
(Phone: Mutual 3300, ext 496)

Office of Under Secretary for Transportation

The Secretary has delegated to the Under Secretary for Transportation the powers, authorities, and discretion conferred on the Secretary under the Defense Production Act, implementing Executive orders and Office of Defense Mobilization delegations with respect to air transportation, intercoastal, coastwise, and overseas shipping, including the use thereof. The Under Secretary for Transportation has in turn redelegated the operating functions under these authorities to major constituent units of the Department. The Office of the Under Secretary for Transportation includes a Transportation Staff and the Defense Air Transportation Administration, both of which assist the Under Secretary in the performance of his defense functions.

Theodore Hardeen, Jr., *Administrator, Defense Air Transportation Administration*	Ext 4707

Bureau of Foreign Commerce

Administers export controls. This involves the determination of the commodities to be controlled; participation in the determination of foreign country requirements and the establishing of quantitative and country export quotas; and the distribution of such quotas among exporters through the issuance of licenses. Priority assistance extended when required.

In addition, the Bureau is responsible for work on national defense programs as related to requirements of foreign countries in mobilization planning and programming.

Office of the Director

	STerling 3–9200, or
Loring K. Macy, *Director*	Code 164, ext 4231
Karl L. Anderson, *Deputy Director*	Ext 3505
H. P. VanBlarcom, *Assistant Director for Foreign Service Operations*	Ext 2392
James C. Foster, *Director, International Resources Staff*	Ext 4260
Carl N. Gibboney, *Director, Foreign Economic Development Staff*	Ext 3643
Erna Hallock, *Acting Director, Publications Staff*	Ext 3681
Rex A. Anderson, *Executive Officer*	Ext 4111

DIVISIONS

John C. Borton, *Director, Office of Export Supply* — Ext 4434
Wallace S. Thomas, *Deputy Director* — Ext 4293
D. P. Medalie, *Director, Investigation Staff* — Ext 8108
Ralph Stewart, *Director, Agricultural and Chemical Products Division* — Ext 3260
Frank Sheaffer, *Director, Finished Products Division* — Ext 2615
John Kilby, *Director, Materials Division* — Ext 3821
Carroll Dunning, *Director, Producers Equipment Division* — Ext 3028
Geraldine S. DePuy, *Director, Operations Division* — Ext 4195
Newton Foster, *Director, Projects and Technical Data Division* — Ext 4250
J. Mishell George, *Director, Strategic Controls Division* — Ext 4358
Robert E. Simpson, *Acting Director, Office of Economic Affairs* — Ext 3532
George Wythe, *Director, American Republics Division* — Ext 2218
Joseph Barkmeier, *Acting Director, British Commonwealth Division* — Ext 3556
Frederick Strauss, *Director, European Division* — Ext 3535
Eugene M. Braderman, *Director, Far Eastern Division* — Ext 3674
Herbert J. Cummings, *Director, Near Eastern and African Division* — Ext 3703
Carl Blackwell, *Director, International Economic Analysis Division* — Ext 3809
E. E. Schnellbacher, *Director, Office of Intelligence and Services* — Ext 3734
Edmund F. Becker, *Director, Commercial Intelligence Division* — Ext 3266
F. Preston Forbes, *Director, International Trade Development Division* — Ext 2276
Herbert Ashton, *Director, Transportation, Communications and Utilities Division* — Ext 8161

Bureau of Public Roads

Cooperates with the States in keeping essential highways in condition to serve traffic resulting from emergency activity. Constructs access roads to defense establishments, defense production plants, and sources of critical materials. The Bureau also has responsibility for development of alternative traffic routes around all major traffic centers and development of plans for the restoration of the transportation plant in the post-attack phase, including the stockpiling of necessary materials and the provision of equipment.

F. V. du Pont, *Commissioner* — EXecutive 3–4950 or Code 1215, ext 4801
A. C. Clark, *Deputy Commissioner, Division of Engineering* — Ext 4028

Maritime Administration

Responsible for developing a merchant marine sufficient for foreign and domestic waterborne commerce capable of serving as a military auxiliary in time of emergency. Its defense functions embrace ship construction and training of merchant seamen, and, within the National Shipping Authority of the Maritime Administration, activities relating to (1) requirements for and allocation of oceangoing merchant shipping, (2) charter, operation, and repair of Maritime Administration-owned or acquired merchant ships, (3) maintenance of reserve fleets, (4) maritime labor policy, (5) purchase, charter in, or acquisition of merchant ships for Government use, and (6) coordination of shipping activities of this Government with those of allied or associated governments on the use of shipping.

Louis S. Rothschild, *Maritime Administrator* — STerling 3–5200 or Code 178, ext 4244
Thos. E. Stakem, Jr., *Acting Deputy Maritime Administrator* — Ext 3196
Charles H. McGuire, *Director, Office of National Shipping Authority and Government Aid* — Ext 5305

Civil Aeronautics Administration

(Temporary Bldg. T–4, 16th Street and Constitution Avenue)

The CAA Office of General Services carries out the allotting agency responsibilities delegated to CAA with respect to civil aircraft and civil aviation operations, including presentation of requirements for air navigation facilities, new civil aircraft and concurrent spares, and maintenance, repair, and operation of civil air carrier aircraft and air navigation facilities; the Office also approves production schedules and makes related allotments of controlled materials for prime consumers producing Class A products pursuant to appropriately authorized programs.

F. B. Lee, *Administrator* — STerling 3–9200, or Code 164, ext 3685
Lewis N. Bayne, *Director, Office of General Services* — Ext 3486

DEPARTMENT OF DEFENSE

(The Pentagon)

Charles E. Wilson, *Secretary of Defense* — LIberty 5–6700 or Code 131, ext 55261
Robert B. Anderson, *Deputy Secretary of Defense* — Ext 56352
Robert T. Stevens, *Secretary of the Army* — Ext 53211
Charles S. Thomas, *Secretary of the Navy* — Ext 53131
Harold E. Talbott, *Secretary of the Air Force* — Ext 53718
W. J. McNeil, *Assistant Secretary of Defense (Comptroller)* — Ext 53237
John A. Hannah, *Assistant Secretary of Defense (Manpower and Personnel)* — Ext 52334

Advises and assists the Secretary of Defense in (1) the establishment of effective policies, programs, and procedures necessary for the efficient and economical operation of the Department of Defense in the fields of manpower and personnel, domestic security, Armed Forces Information and Education, and administration and maintenance of Reserve Forces, and (2) the effective internal administration of the Office of the Secretary of Defense.

Fred A. Seaton, *Assistant Secretary of Defense (Legislative and Public Affairs)* — Ext 79312
Frank C. Nash, *Assistant Secretary of Defense (International Security Affairs)* — Ext 56273

Advises and assists the Secretary of Defense in the establishment of Department of Defense views and positions on and in the coordination of all activities within the Department relating to International Security Affairs including Mutual Defense Assistance Programs, North Atlantic Treaty Affairs, United Nations Affairs, National Security Council actions, intergovernmental conferences, and other similar politico-military matters.

Donald A. Quarles, *Assistant Secretary of Defense (Research and Development)* — Ext 79101

Advises and assists the Secretary of Defense in the establishment of effective policies and procedures necessary for accomplishing a sound and integrated research and development program for the Department of Defense and in assuring the interaction of research and development with strategy.

Frank D. Newbury, *Assistant Secretary of Defense (Applications Engineering)* — Ext 79111

Advises and assists the Secretary of Defense in the establishment of policies, procedures, and standards necessary for the efficient and economical operation of the Department of Defense in the engineering phases of development, design, and production (including standardization, modification, and maintenance) of military applications for weapons and weapons systems and their timely introduction into quantity production.

Thomas P. Pike, *Assistant Secretary of Defense (Supply and Logistics)* — Ext 55254

Advises and assists the Secretary of Defense in the establishment of effective policies and systems necessary for the efficient and economical operation of the Department of Defense in supply and logistics fields of procurement, production, distribution, transportation, communications, storage, cataloging, requirements, and mobilization planning.

Franklin G. Floete, *Assistant Secretary of Defense (Properties and Installations)* — Ext 79155

Advises and assists the Secretary of Defense in the establishment of effective policies and systems necessary for the efficient and economical operation of the Department of Defense in the fields of real estate acquisitions, utilization and disposal, construction, real property maintenance and management, reserve facilities, and family housing.

Frank B. Berry, *Assistant Secretary of Defense (Health and Medical)* — Ext 72111

Advises and assists the Secretary of Defense in the establishment of effective policies, programs, and systems necessary for the efficient and economical operation of the Department of Defense in the fields of health and sanitation, medical care and treatment of patients, and administration of hospitals and related treatment facilities.

Wilbur M. Brucker, *General Counsel* — Ext 54351
Admiral Arthur W. Radford, *Chairman, Joint Chiefs of Staff* — Ext 79121

DEFENSE TRANSPORT ADMINISTRATION

(Interstate Commerce Commission Bldg., 12th Street and Constitution Avenue)

Formulates and carries out national defense plans and programs with respect to domestic transportation, storage, and port facilities, except for air transport, pipelines, coastwise, intercoastal, and overseas shipping.

James K. Knudson, *Administrator* — REpublic 7–7500 or Code 151, ext 6516
Homer C. King, *Deputy Administrator* — Ext 6403
Francis A. Silver, *General Counsel* — Ext 5274
Clarence Barker, *Administrative Officer* — Ext 3513

Tax Amortization and Defense Loans Group

David Homer, *Director* — Ext 8151

Mobilization and Transport Specialists

Warren C. Kendall — Ext 4269
Harold K. Osgood — Ext 4240
Henry R. Pellegrino — Ext 4447
William J. Gregg — Ext 5833
Eugene S. Root — Ext 4269

DEPARTMENT OF THE INTERIOR

(C Street between 18th and 19th Streets NW.)

Interior performs operations relating to priorities, allocations, and voluntary agreements with respect to petroleum, gas, solid fuels, electric power, and fishery products. It has responsibilities in connection with productive capacity expansion for these commodities and it reviews and makes recommendations on application for necessity certificates for accelerated tax amortization, loans, guarantees, and commitments to purchase. It also makes loans to encourage the exploration of critical and strategic minerals and metals.

Douglas McKay, *Secretary* — REpublic 7–1820 or Code 181, ext 704
Ralph A. Tudor, *Under Secretary* — Ext 4423

Fred G. Aandahl, *Assistant Secretary, Water and Power Development* Ext 2191
Orme Lewis, *Assistant Secretary, Public Land Management* Ext 4174
Felix E. Wormser, *Assistant Secretary, Mineral Resources* Ext 2186
D. Otis Beasley, *Administrative Assistant Secretary* Ext 2143

TECHNICAL REVIEW STAFF

Robert E. Day, *Staff Assistant (Defense Matters)* Ext 4231
Frederick P. Hobart, *Staff Assistant (Defense Matters)* Ext 2425

Defense Minerals Exploration Administration

C. O. Mittendorf, *Administrator* Code 181, ext 5371
Frank E. Johnson, *Deputy Administrator* Ext 5369
George C. Selfridge, *Special Assistant* Ext 5372
J. L. Hofflund, *Chief Counsel* Ext 2917
William S. Martin, *Chief, Iron and Ferro-Alloy Division* Ext 5284
Willis R. Griswold, *Chief, Base Metals Division* Ext 3669
Ernest William Ellis, *Chief, Rare and Miscellaneous Metals Division* Ext 5295
Lawrence G. Houk, *Chief, Nonmetallic Minerals Division* Ext 2971
Jay L. Chambers, *Chief, Contract Administration and Audit Division* Ext 3461
Robert E. Adams, *Chief, Operations Control and Statistics Division* Ext 2017

Power Unit—Office of the Assistant Secretary—Water and Power Development

Gardiner George, *Power Material Coordinator* Code 181, ext 2827
George English, *Power Supply Coordinator* Ext 2577

Defense Solid Fuels Administration

William F. Hahman, *Administrator* Code 181, ext 5391
Leo N. Plein, *Industrial Specialist (Industry Finance)* Ext 5391

Fish and Wildlife Service

John L. Farley, *Director* Code 181, ext 4717
A. W. Anderson, *Chief, Branch of Commercial Fisheries (Defense Matters)* Ext 4386

Oil and Gas Division*

Hugh A. Stewart, *Director* Ext 3831
Carroll D. Fentress, *Assistant Director* Ext 3891
Bernice Kirschling, *Special Assistant to the Director* Ext 3601

DEPARTMENT OF AGRICULTURE

(14th Street and Independence Avenue SW.)

Has responsibility for maintaining continuous supplies of food and the domestic distribution of farm equipment and commercial fertilizers.

REpublic 7–4142 or
Ezra Taft Benson, *Secretary* Code 161, ext 3631
True D. Morse, *Under Secretary* Ext 6158
Coordination for Defense Mobilization:
L. B. Taylor Ext 4744
Bruce M. Easton Ext 3152
Earl W. Loveridge, *Assistant Chief, Forest Service* Ext 3715
Fred H. Strong, *Deputy Administrator, Rural Electrification Administration* Ext 3243

*The Oil and Gas Division has assumed defense mobilization responsibilities for oil and gas upon termination of the Petroleum Administration for Defense.

FEDERAL RESERVE BOARD

(20th Street and Constitution Avenue NW.)

The Board of Governors of the Federal Reserve System issues regulations in regard to loans guaranteed in accord with Section 301 of the Defense Production Act and real estate credit.

REpublic 7–1100 or
William McC. Martin, Jr., *Chairman* Code 132, ext 201
Gardner L. Boothe II, *Administrator, Office of Defense Loans* Ext 571

RECONSTRUCTION FINANCE CORPORATION

(811 Vermont Avenue NW.)

Processes and administers loans under Section 302 of the Defense Production Act of 1950, as amended, and Section 409 of the Federal Civil Defense Act, pursuant to authority granted by the Secretary of the Treasury.

EXecutive 3–3111 or
Lawrence B. Robbins, *Administrator* Code 168, ext 1
Frank T. Ronan, *Director, Office of Loans* Ext 55
Edward T. Stein, *Assistant Director, Office of Loans* Ext 328

HOUSING AND HOME FINANCE AGENCY

(1626 K Street NW.)

Handles the program for provision of needed defense housing and community facilities in critical defense housing areas, under the Defense Housing and Community Facilities and Services Act of 1951, as amended. (This program expires June 30, 1954.) Under Defense Mobilization Order I–3, the Agency is represented on the Defense Areas Advisory Committee in the Office of Defense Mobilization, which is responsible for making recommendations for the designation of critical defense housing areas. Under Defense Mobilization Order I–1, the Agency is represented on the Regional Defense Mobilization Committees. Under Defense Mobilization Order VII–5, the Administrator is designated to present supply and requirements information to ODM with respect to housing construction, alteration, and repair, except housing and community facilities owned property under the control of the Atomic Energy Commission, and housing on military reservations.

EXecutive 3–4160 or
Albert M. Cole, *Administrator* Code 183, ext 2417
Annabelle Heath, *Administrative Assistant* Ext 2417
B. T. Fitzpatrick, *General Counsel* Ext 2444
Neal J. Hardy, *Assistant Administrator* Ext 2511
Burton O. Young, *Director, Defense Programs* Ext 2651
Ashley A. Foard, *Assistant General Counsel* Ext 2695
Adolph Zwerner, *Director, Division of Law* Ext 2446
John C. Hazeltine, *Commissioner, Community Facilities and Special Operations* Ext 3171
Jack H. Bryan, *Director, Division of Information* Ext 2486
Robert R. Poston, *Congressional Liaison* **Ext 2673**

GENERAL SERVICES ADMINISTRATION

(18th and F Streets NW.)

Plans, develops, coordinates, and administers all programs relating to the research and development, procurement, storage, transportation, refining, processing, rotation and disposal of a stockpile of strategic and critical materials essential to the military and industrial requirements in times of national emergency. Purchases and makes commitments to purchase metals, minerals, and other materials for Government use or resale; encourages the exploration, development, and mining of minerals and metals at home and abroad.

EXecutive 3–4900 or
Edmund F. Mansure, *Administrator* Code 156, ext 4312
Al E. Snyder, *Assistant Administrator* Ext 4312

Emergency Procurement Service

(7th and D Streets SW.)

REpublic 7–7500 or
A. J. Walsh, *Commissioner* Code 151, ext 2243
William M. B. Freeman, *Special Assistant to the Commissioner* Ext 5128
F. W. Witt, *Coordinator of Sales* Ext 5669
H. C. Maull, Jr., *Director, Purchase Division* Ext 2672
George K. Casto, *Director, Rubber Division* Ext 5338
Irving Gumbel, *Acting Director, Materials Division* Ext 4121
Tom V. Wilder, *Director, Materials Research and Analysis Division* Ext 6356
Joseph E. Salisbury, *Director, Storage and Transportation Division* Ext 3432
H. C. Cleveland, *Administrative Officer* Ext 4691

SMALL BUSINESS ADMINISTRATION

(811 Vermont Avenue NW.)

SBA insures that the productive capacity of small-business concerns will be effectively utilized for the national defense and essential civilian production. Government procurement is to be expedited and bottlenecks eliminated by spreading procurement to small-business concerns and by careful review of the distribution of critical materials insuring that small businesses receive a fair proportion of Government contracts. SBA makes loans to small-business concerns to finance plant construction, conversion, expansion, or acquisition of machinery and supplies or for working capital, and develops and provides managerial and technical aids. It also makes disaster loans to relieve distress and hardship attendant upon floods, windstorms, fires, and other catastrophes.

STerling 3–2858 or
Wendell B. Barnes, *Administrator* Code 1276, ext 3615
Donald A. Hipkins, *Deputy Administrator* Ext 3686
Robert H. Montgomery, *Deputy Administrator* Ext 3293
William N. Engles, *Deputy Administrator* Ext 3395
Information and Managerial Assistance—Arthur W. Hachten Ext 3256
Office Directors:
General Counsel—Edward Schoen Ext 3761
Production and Procurement Assistance—Theodore G. Waale Ext 2017
Financial Assistance—William L. Rollins Ext 3583
Management—Raymond L. Schafer (Acting Director) Ext 3581
Controller—Keith L. Hanna Ext 475
Economic Adviser—Jules Abels Ext 3392

Directory of SBA Regional and Branch Offices

REGION I—Boston, Mass.

(Covering Maine, New Hampshire, Vermont, Rhode Island, Massachusetts, and Connecticut (except Fairfield County))

Edward J. Stewart, *Regional Director, Small Business Administration*
40 Broad Street, Boston 9, Mass. Phone: Hubbard 2–6200, ext 96

Branch Office—Hartford, Conn.

Kenneth L. Childs, *Acting Branch Manager*
Arch Bldg., 70 Arch St., Hartford, Conn.

REGION II—New York, N. Y.

(Covering New York, Fairfield County, Connecticut, and New Jersey (except the following counties: Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Mercer, Ocean, and Salem))

J. Frederic Benedict, *Regional Director, Small Business Administration*
2 Park Avenue, 12th Floor
New York 16, N. Y. Phone: Murray Hill 5–5900

Branch Office—Buffalo, N. Y.

A. S. Posage, *Branch Manager, Small Business Administration*
121 Ellicott Street, U. S. Post Office Bldg., Room 507
Buffalo 3, N. Y. Phone: Madison 5972

REGION III—Philadelphia, Pa.

(Covering Pennsylvania, Delaware, and following counties of New Jersey: Mercer, Ocean, Burlington, Camden, Gloucester, Atlantic, Salem, Cumberland, and Cape May)

William Henry Harman, *Regional Director, Small Business Administration*
1015 Chestnut Street, Room 1118
Philadelphia 7, Pa. Phone: Walnut 2–8770, ext 380

Branch Office—Pittsburgh, Pa.

Fernand A. Thomassy, *Branch Manager, Small Business Administration*
1019 Clark Bldg., 717 Liberty Avenue
Pittsburgh 22, Pa. Phone: Grant 1–5370, ext 398

REGION IV—Richmond, Va.

(Covering Virginia, District of Columbia, Maryland, North Carolina, and West Virginia)

Clarence P. Moore, *Regional Director, Small Business Administration*
Southern States Bldg., Seventh and Main Streets
Richmond 19, Va. Phone: Richmond 3–3561

Branch Office—Baltimore, Md.

Harry A. Barron, *Branch Manager, Small Business Administration*
Calvert Bldg., Room 307, Fayette and St. Paul Streets
Baltimore, Md. Phone: Plaza 2–8460, ext 480

Branch Office—Charleston, W. Va.

Gadsden E. Shard, *Acting Branch Manager*
Room 103, Berman Bldg., 612 Virginia St., Charleston, W. Va.
Phone 3–2232

REGION V—Atlanta, Ga.

(Covering Georgia, Alabama, Florida, Mississippi, South Carolina, Tennessee, Commonwealth of Puerto Rico, and the Virgin Islands)

Dwight F. Entwistle, *Regional Director, Small Business Administration*
Peachtree Seventh Bldg., Room 263, 50 Seventh Street NE.
Atlanta, Ga. Phone: Elgin 3311, ext 5506

Branch Offices—Birmingham, Ala., and Nashville, Tenn.

Hugh W. Mitchell, *Branch Manager, Small Business Administration*
206 Social Security Bldg., Third Avenue and 23d Street
Brimingham, Ala. Phone: 53–3421, ext 200

Charles D. Hopkins, *Branch Manager, Small Business Administration*
U. S. Courthouse, Eighth Avenue and Broad Street, Room 663
Nashville, Tenn. Phone: 42–9651, ext 779

REGION VI—Cleveland, Ohio

(Covering Ohio, Kentucky, and Michigan)

Don Williams, *Regional Director, Small Business Administration*
Ferguson Bldg., Room 248, 1783 East 11th Street
Cleveland 14, Ohio Phone: Cherry 1–7900, ext 580

Branch Offices—Cincinnati, Ohio, and Detroit, Mich.

George F. Baker, *In Charge, Small Business Administration*
710 Big Four Bldg., 230 East Ninth Street
Cincinnati 2, Ohio Phone: Dunbar 2200, ext 359

James B. Shepard, *Branch Manager, Small Business Administration*
Federal Bldg., Room 620, 231 West Lafayette Boulevard
Detroit 26, Mich. Phone: Woodward 3–9330, ext 517

REGION VII—Chicago, Ill.

(Covering Illinois, Indiana, and Wisconsin)

William H. Kelley, *Regional Director, Small Business Administration*
226 West Jackson Boulevard, Room 1401
Chicago 6, Ill. Phone: Andover 3–3600, ext 355

Branch Offices—Indianapolis, Ind., and Madison, Wis.

Martin H. Fuller, *Branch Manager, Small Business Administration*
521 Federal Bldg., Indianapolis, Ind. Phone: Market 1561, ext 536

Robert W. Davis, *Branch Manager, Small Business Administration*
Woolworth Bldg., 105 Monona Avenue
Madison, Wis. Phone: Madison 6–2696

REGION VIII—Minneapolis, Minn.

(Covering Minnesota, Montana, North Dakota, and South Dakota)

J. Walter Malmquist, *Regional Director, Small Business Administration*
220 Minnesota Federal Bldg., Marquette Avenue at Sixth
Minneapolis 2, Minn. Phone: Main 3244—Nestor 2541

Branch Office—Helena, Mont.

William T. Beaumont, *Branch Manager*
Power Block, Helena, Mont. Phone: 4464

REGION IX—Kansas City, Mo.

(Covering Missouri, Iowa, Kansas, and Nebraska)

C. I. Moyer, *Regional Director, Small Business Administration*
Federal Office Bldg., Room 1402, 911 Walnut Street
Kansas City 6, Mo. Phone: Baltimore 7000, ext 8–765

Branch Offices—Davenport, Iowa; Omaha, Nebr.; and St. Louis, Mo.

Hal P. McCarthy, *In Charge, Small Business Administration*
215 Main Street, Putnam Bldg., Room 313
Davenport, Iowa

Lyle S. MacKenzie, *In Charge, Small Business Administration*
Federal Office Bldg., Room 209, 15th and Dodge Streets
Omaha 2, Nebr. Phone: Jackson 7900, ext 692

John Darr, *In Charge, Small Business Administration*
New Federal Bldg., Rooms 924–928, 1114 Market Street
St. Louis 1, Mo. Phone: Main 8100, ext 2191

REGION X—Dallas, Tex.

(Covering Texas, Arkansas, Louisiana, and Oklahoma)

Henry H. Ritter, *Acting Regional Director, Small Business Administration*
1114 Commerce Street, Dallas 2, Tex.

Branch Offices—Houston, Tex.; New Orleans, La.; and Oklahoma City, Okla.

Small Business Administration
Federal Office Bldg., Room 306, Fannin and Franklin Streets
Houston 2, Tex. Phone: Capitol 7201, ext 044–045

Wren W. Anderson, *Branch Manager, Small Business Administration*
Masonic Temple Bldg., Room 718, 333 St. Charles Street
New Orleans 12, La. Phone: Canal 3481, ext 51

Small Business Administration
Insurance Bldg., Room 712, 114 North Broadway
Oklahoma City, Okla. Phone: Regent 6–5601, ext 226

REGION XI—Denver, Colo.

(Covering Colorado, New Mexico, Utah, and Wyoming)

Harold R. Smethills, *Regional Director, Small Business Administration*
New Customhouse, Room 235, 19th and Stout Streets
Denver 2, Colo. Phone: Keystone 4151, ext 8298

REGION XII—San Francisco, Calif.

(Covering Nevada and the following California counties: Alameda, Alpine, Amador, Butte, Calaveras, Colusa, Contra Costa, Del Norte, Eldorado, Fresno, Glenn, Humboldt, Kings, Lake, Lassen, Madera, Marin, Mariposa, Mendocino, Merced, Modoc, Mono, Monterey, Napa, Nevada, Placer, Plumas, Sacramento, San Benito, San Francisco, San Joaquin, San Mateo, Santa Clara, Santa Cruz, Shasta, Sierra, Siskiyou, Solano, Sonoma, Stanislaus, Sutter, Tehama, Trinity, Tulare, Tuolumne, Yolo, and Yuba)

Homer F. Potter, *Regional Director, Small Business Administration*
870 Market Street, Flood Building, Room 1248,
San Francisco 2, Calif. Phone: Klondike 2–2350, ext 6923

REGION XIII—Seattle, Wash.

(Covering Washington, Idaho, Oregon, and the Territory of Alaska)

Edgar D. Peterson, *Acting Regional Director, Small Business Administration*
Burke Bldg., 905 Second Avenue
Seattle, Wash. Phone: Mutual 3300

Branch Office—Portland, Oreg.

John G. Barnett, *Branch Manager, Small Business Administration*
U. S. Courthouse (Old), 520 SW. Morrison Street
Portland 4, Oreg. Phone: Broadway 8471

REGION XIV—Los Angeles, Calif.

(Covering Arizona and the following California counties: Imperial, Inyo, Kern, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura)

Joseph V. Ragusa, *Acting Regional Director, Small Business Administration*
117 West Ninth Street, Suite 711,
Los Angeles 15, Calif. Phone: Prospect 4711, ext 316

Branch Office—Phoenix, Ariz.

Gordon W. Boudreau, *Branch Manager, Small Business Administration*
Ellis Building, Room 209, Phoenix, Ariz.

DEPARTMENT OF LABOR

(14th Street and Constitution Avenue NW.)

The Assistant Secretary for Employment and Manpower is head of the Office of Manpower Administration. Subject to the direction of the Secretary of Labor, he is responsible for developing, for both partial and total mobilization, plans, policies, and programs for meeting defense manpower requirements and for supervising, directing, and coordinating such activities in the Department through the appropriate Bureau Directors.

EXecutive 3–2420 or
James P. Mitchell, *Secretary* Code 177, ext 1

Office of Manpower Administration
Rocco C. Siciliano, *Assistant Secretary for Employment and Manpower* Ext 7
Leo R. Werts, *Deputy Assistant Secretary for Manpower* Ext 215
George Tobias, *Manpower Program Specialist* Ext 644

Office of Solicitor
Stuart Rothman, *Solicitor* Ext 10

Office of Information
Herbert Little, *Director* Ext 24

Bureau of Labor Statistics
Ewan Clague, *Commissioner* Ext 1110

Bureau of Labor Standards
Paul Gursky, *Director* Ext 1100

Bureau of Employment Security
Robert C. Goodwin, *Director* Ext 780

Bureau of Apprenticeship
William F. Patterson, *Director* Ext 546

Bureau of Veterans' Reemployment Rights
Robert K. Salyers, *Director* Ext 627

Women's Bureau
Alice K. Leopold, *Director* Ext 36

Wage and Hour and Public Contracts Division
William R. McComb, *Administrator* Ext 1200

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